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SERUM LIPIDS IN YOUNG MEN DURING MILITARY SERVICE

BY

AARNE KONTTINEN

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AARNE KONTTINEN

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PREFACE

The investigation reported here was carried out in 1957—1959 at the Wihuri Research Institute. The subject of investigation was selected at the suggestion of my respected teacher, Professor Pentti I. Halonen, M.D., head of the Institute and chief of the Third Medical Clinic, University of Helsinki. It is my pleasant duty to express to Professor Halonen my sincere thanks for placing the laboratory facilities of the Wihuri Research Institute at my disposal and for giving me the benefit of his experienced supervision and valuable advice.

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Helsinki, October 1959

Aarne Konttinen

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INTRODUCTION

Serum lipids have been a subject of wide interest, especially in research on atherosclerosis. Following the observation by some investigators that coronary heart disease is more rarely encountered in physically active persons than in the less active, increasing interest has developed also towards the relationship between physical exercise and the serum lipids.

The effect of physical activity on the serum lipids has been studied in human subjects in connection with increased physical activity of short duration and in a number of animal experiments. On the other hand, very few reports have been published on the relationship between physical activity of longer duration and the serum lipids in man. The carrying out of the present investigation therefore appeared to be justified as an attempt to add to our knowledge of this subject.

Physical activity requires a supply of energy in the form of food, and since numerous investigations have shown that nutritional factors influence the serum lipids, a review is first made of the literature on the effect of nutritional factors on the serum lipids.

REVIEW OF THE LITERATURE

DIETARY FACTORS AND BLOOD LIPIDS

In investigations made for the purpose of throwing light on the effect of various nutritional factors on the serum lipids and lipoproteins, special attention has been paid to the dietary cholesterol, amount of dietary fats, and comparison of animal and vegetable fats in the diet. In recent years, the fatty acid content of dietary fats and also, to some extent, the phytosterols have become subjects of intensive investigation. Less research work has been carried out on the relationships between the total calorie content, proteins, carbohydrates and certain vitamins in the diet and the serum lipids and lipoproteins.

It is interesting to observe that certain statements concerning dietary effects on the fat content in the blood were made already at the time the estimation of the fat content was based on macroscopic changes in the blood. Thus Bartholinus (1654) and Clauderus (1689) suggested that a fat diet increases the fat content in human blood. Hewson (1780) observed in geese a milky blood with profuse fat globules after being fed with fat and milk. Schreger (1823) mentioned that hogs fed on fruits had less fat in the blood than hogs feeding on garbage.

Christison (1831) possibly was the first to make quantitative determinations of the fat content of blood. Presumably the first observation that human blood contains cholesterol was made by Lecany (1838). However, only much later the methods of determination of fats were sufficiently far advanced to be applicable to more exact determinations of the different blood lipids. For example, the first more accurate method of quantitative cholesterol determination was presented by Windaus (1910a).

Bleibtreu (1901) found that the feeding of fat increased the fat content of the blood in geese. Pribram (1906) and Fraser

and Gardner (1910) observed the increase in the blood cholesterol of rabbits fed on diets containing cholesterol. Interest was concentrated on the relationship between dietary cholesterol and blood cholesterol also in human subjects after Windaus (1910b) had demonstrated that the human atherosclerosis plaque contains a large amount of cholesterol, and Anitschkow and Chalatow (1913) had produced vascular changes simulating atherosclerosis in rabbits fed cholesterol.

Cholesterol

During the first decades of the present century the resorption of cholesterol from the intestines into the blood was studied after the ingestion of foods with a high cholesterol content. Bacmeister and Henes (1913) observed that a high-cholesterol meal produced a postprandial increase in the cholesterol in human blood, and Henes (1913) found, in addition, a rise in the blood lecithin and total lipids.

Luden (1917) was possibly the first to study the blood cholesterol during a prolonged dietary experiment. In experiments on herself she observed that on prolonged feeding with a vegetable diet the blood cholesterol was diminished but with an exclusively meat diet it was increased. Mjassnikow (1926) added daily 2 g of pure cholesterol to the food but found no rise in the blood cholesterol in healthy subjects, whereas in patients with nephrosis or atherosclerosis it was frequently, but not always, increased during prolonged ingestion of cholesterol.

Variations in the cholesterol content of the »normal» human diet have been found not to have an effect on the serum cholesterol level (Keys *et al.* 1950b, Gertler *et al.* 1950b, Keys and Keys 1954, Keys *et al.* 1956c). The diet of adult males in, for example, the United States, where the consumption of eggs, meat and dairy products is high, contains about 250—800 mg of cholesterol per day (Keys *et al.* 1950b). The addition of cholesterol to the diet in physiological amounts has also not been found to raise the serum cholesterol (Beveridge *et al.* 1955, Keys *et al.* 1956c, Bronte-Stewart *et al.* 1956). Plasma cholesterol was observed to increase, however, when cholesterol was supple-

mented to the low-fat diet with a distillation fractions of butter oil but not with certain fatty acid fraction of coconut oil (Beveridge *et al.* 1959). The authors suggested that dietary cholesterol may produce a rise in plasma cholesterol depending upon the fat with which it is associated in the diet.

There also have been published dietary experiments with human subjects, studying the effect on the serum cholesterol of cholesterol supplements in unphysiologically large amounts. Messinger *et al.* (1950) added 30 g of crystalline cholesterol to the diet and observed a smaller rise in the serum cholesterol than after the feeding of egg yolk powder, although the amount of cholesterol in the egg yolk was only about one-tenth of that given in crystalline form. Kinsell *et al.* (1953a, 1953b) found that the addition of 30—60 g of cholesterol daily to the diet resulted in no significant elevation of serum cholesterol.

Amount of Fats

Kempner's low-fat rice diet containing 3—5 g of fat in about 2000 kcal per day has been observed to cause a fall in the serum cholesterol level (Kempner 1946, 1948, 1949, Schwartz and Merlis 1948, Starke 1950, Chapman *et al.* 1950, Keys *et al.* 1950b, Watkin *et al.* 1950, Newborg and Kempner 1955, Hatch *et al.* 1955). A reduction in the phospholipids was also observed by Kempner (1949), whereas Hatch *et al.* (1955) found no consistent change in the phospholipids when this diet was used.

Mellinkoff *et al.* (1950) obtained a decrease in the serum cholesterol concentration with an entirely fat-free diet. Gofman *et al.* (1950) reported that a low-fat diet results in a decrease in the level of S_f 10—20 lipoproteins determined by ultracentrifugation. It was indeed, emphasized by Gofman *et al.* (1951) that certain of the lipoproteins reflect changes in the serum lipids, which may escape notice if the total cholesterol and total phospholipids only are determined. Keys *et al.* (1955a) observed on a low-fat diet a decrease in the serum total cholesterol and in the cholesterol of the lipoprotein fractions separated by paper electrophoresis, whereas the S_f 12—20 lipoproteins determined by Gofman's method were not changed.

Attempts have been made to elucidate the relations between the amount of dietary fat and serum lipids also by studies carried out among different populations. One of the first to draw attention to the blood cholesterol level of a population in the light of its nutritional factors was de Langen (1922). Stone (1936) and Squires (1941) recorded the conspicuously low serum cholesterol levels of South African natives. It was reported by Walker and Arvidsson (1954) that the serum cholesterol in South African Bantu negroes was lower than in local Europeans. Ruskin *et al.* (1958) stated that the S_f 12—100 lipoprotein levels of the Bantus were lower than those of white New York city individuals. A lower serum cholesterol level in Australian natives using a low-fat diet than in local Europeans using more fat in the diet was found by Schwartz *et al.* (1957). Likewise, Shaper and Jones (1959) noted higher serum cholesterol level in Uganda in Asians, who used more fat in the diet than in Africans in the same area consuming less fat. According to studies by A. Keys and his working groups, the serum total cholesterol and β-cholesterol levels of population groups in different countries are correlated to the percentage of fat calories in the diet (Keys *et al.* 1955a). Among the rural populations of Guatemala (Mann *et al.* 1955a) and Nigeria (Mann *et al.* 1955b) the serum cholesterol levels were lower than in North American subjects, whereas no consistent difference was seen in the lipoproteins determined with the ultracentrifuge. The authors were of the opinion that the low fat content of the diets of the populations studied does not provide an adequate explanation for the difference observed in the serum cholesterol alone but not in the lipoproteins.

Page *et al.* (1956) suggested that racial factors are the cause of the low serum cholesterol level of the Navajo Indians. Studying the possible influence of racial factors, Bersohn and Wayburne (1956) investigated in Africa the serum cholesterol concentration of native and European mothers and their new-born infants. The low cholesterol levels of the African mothers and both groups of infants and the high cholesterol level of the European mothers cannot, in their opinion, be accounted for on the base of racial factors. Toor *et al.* (1957) found that the serum cholesterol and total lipid concentrations among Yemenite immi-

grants in Israel was dependent on their standard of living. It was noted by Scrimshaw *et al.* (1957a) that the serum cholesterol level of Guatemalan school children was dependent on the socio-economic standard of their families. According to the studies by Keys *et al.* (1958c) the β-cholesterol level in the serum of Japanese living in different countries exhibited great variations and a linear relationship to the percentage of calories provided by fats in the diet. Likewise Padmavati *et al.* (1959) found the serum total cholesterol to be higher in high-income groups than in low-income groups of Indian population.

Vegetable contra *Animal Fats*

In a number of investigations it was noted that the serum cholesterol decreased during a low-fat diet and increased again upon the addition of fat, whether of animal or vegetable origin (Keys *et al.* 1950b, Hildreth *et al.* 1951, Mayer *et al.* 1954). In the investigations of Groen *et al.* (1952) it was observed that the serum cholesterol level may be independent of the amount of fat intake and attributable to difference in the effect of animal and vegetable fats.

Hardinge and Stare (1954) and Nath *et al.* (1957) reported that the serum cholesterol levels of vegetarian groups were lower than those of non-vegetarian groups. In a study of Europeans, Bantu negroes and colored persons in Capetown, Bronte-Stewart *et al.* (1955) found that the serum cholesterol and the β-cholesterol were correlated to the amount of animal fat in their diets. Brožek *et al.* (1957) stated in Yugoslavia a higher serum cholesterol level in the population in an area where animal fat was used than in another area where the dietary fat consisted mostly of olive oil.

It has been observed in many experiments that the substitution of fat of vegetable origin for animal fat resulted in a fall in the plasma cholesterol and phospholipids (Kinsell *et al.* 1953a, 1953b, 1954, Cochrane *et al.* 1953, Ahrens *et al.* 1954, Beveridge *et al.* 1955). Similarly, Wollaeger *et al.* (1953) reported that a fat-free diet decreased the plasma cholesterol from the level

observed during a mixed diet. The low cholesterol level was maintained when triolein was substituted for a part of the carbohydrates in the fat-free diet.

Fatty Acids

The classification of fats into animal and vegetable fats breaks in many ways the uniformity of a classification made according to their chemical structure. Kinsell and Michaels (1955) suggested that the unsaturated fatty acid content of vegetable fats may provide an explanation for their previously published observations concerning the decreasing effect of vegetable fats on the serum lipids. This suggestion stimulated research work on the effect of different dietary fats on the serum lipids on the base of the chemical structure of these fats. Numerous investigators have observed that highly unsaturated dietary fats, such as corn oil, sunflower seed oil and cotton seed oil, depress the serum cholesterol, phospholipid and β-lipoprotein levels when these oils are *substituted* for the highly saturated fats in the diet, such as butter, lard and coconut oil (Malmros and Wigand 1955, 1957, Bronte-Stewart *et al.* 1956, Ahrens *et al.* 1957, Beveridge *et al.* 1957, 1958, Keys *et al.* 1957a, Anderson *et al.* 1957a, Shapiro *et al.* 1957, Horlick and Craig 1957, Brown and Page 1958, Boyer *et al.* 1959, Terman 1959).

Observations on the effect of the *addition* of fats containing unsaturated fatty acids to the diet appear to be less consistent. The addition of sunflower seed oil to the standard diet caused no clear response in the serum cholesterol and β-lipoproteins (Linko 1957a). Similarly, when corn oil was added to a diet low in animal fats, by which the serum cholesterol and low-density lipoproteins had previously been reduced, no change occurred in the serum lipids (Engelberg and Hills 1957). On the other hand, a decrease in the plasma cholesterol was seen on the addition of corn oil to a nearly fat-free diet (Beveridge *et al.* 1956, 1958) and to a low-fat diet (Rhoads and Barker 1959). An increase in the ingested amount of corn oil resulted in a fall in the serum cholesterol, phospholipids and triglycerides (Ahrens *et al.* 1957). Similarly, the addition of sunflower seed oil to a

diet rich in animal fat (Bronte-Stewart *et al.* 1956) and to a »normal diet» (Gordon and Brock 1958) depressed the serum cholesterol.

The influence on the serum lipids of a number of other vegetable oils containing unsaturated fatty acids has also been studied. Thus it was observed by many investigators that the substitution of safflower oil for the animal fats in the diet resulted in a reduction in the serum cholesterol (Ahrens *et al.* 1957, Armstrong *et al.* 1957, Farquhar and Sokolow 1958, Hashim *et al.* 1959). The giving of this oil in addition to the usual diet had also a depressant effect on the serum cholesterol, as reported by leRiche (1957) and McCann *et al.* (1959). However, no depressant effect of safflower oil added to the diet was found by Perkins *et al.* (1958, 1959) or by Nikkilä and Jokipii (1959). In experiments by Malmros and Wigand (1957) the substitution of rapeseed oil for saturated fats produced a moderate decrease in the serum cholesterol level. Linko (1957a) observed that rapeseed oil added to the diet lowered somewhat the serum cholesterol and β-lipoprotein levels. Addition of linseed oil to the diet decreased the serum lipids (Schettler and Eggstein 1958), but in cases of recent myocardial infarction this occurred with only a part of the patients (Linko 1957b). Added soyabean oil lowered the serum cholesterol during the first week, but consistent results were not obtained with long-term use (Wolff *et al.* 1958).

Olive oil, the fatty acid glycerides of which are chiefly composed of mono-ethenoids, i.e., fatty acids containing one double bond, has no influence on the serum cholesterol in the opinion of some investigators (Keys *et al.* 1957c, 1958a, Michaels *et al.* 1958, Kinsell *et al.* 1958), produces at the most a slight decrease (Malmros and Wigand 1957), or causes a definite fall (Armstrong *et al.* 1957).

A number of marine oils have also been found to lower the serum cholesterol, as compared with fats containing saturated fatty acids. This effect was observed by Bronte-Stewart *et al.* (1956), with seal, arachis and pilchard oils, by Gordon and Brock (1958) with pilchard oil, by Keys *et al.* (1957a) and Anderson *et al.* (1957a) with sardine oil, by Ahrens *et al.* (1959) with menhaden oil, and by Malmros and Wigand (1957) with

unsaturated whale oil; when saturated, the whale oil lost its depressing effect on the serum cholesterol.

Opinions diverge concerning the factor or factors in the above mentioned vegetable and marine oils that may be responsible for the serum lipid-depressing effect. Ahrens *et al.* (1957) and Ahrens (1957) have suggested that the degree of saturation of the glyceride fatty acids, expressed as the iodine value of the fats, would provide the explanation for the observed changes. For example, it was reported by Bronte-Stewart *et al.* (1956) that sunflower seed oil and peanut oil and by Gordon and Brock (1958) that sunflower seed oil lost in the saturated form their ability to lower the serum lipids. However, this is contradicted by the observation that hydrogenated corn oil reduced the cholesterol in the same manner as did its unsaturated form (Beveridge *et al.* 1958).

It has been suggested that the »essential» fatty acids, especially linoleic acid with two double bonds, are responsible for the decrease in the serum lipids (Kinsell *et al.* 1956, 1958, 1959). The human organism is unable to synthesize these »essential» fatty acids. Michaels *et al.* (1958) showed that pure ethyl linoleate and trilinolein lowered the plasma lipids, whereas ethyl oleate and triolein did not have this effect. They concluded that the linoleic acid is largely or entirely responsible for the plasma lipid changes associated with the administration of vegetable fats. On the other hand, again, Armstrong *et al.* (1957) observed that non-essential olive oil containing mono-ethenoid fatty acids lowered the serum cholesterol level. It was found by Worne *et al.* (1959) that the addition of a mixture of various unsaturated fatty acids to the diet reduced the blood cholesterol. Likewise, Worne and Smith (1959) noted that the feeding of various pure essential poly-unsaturated fatty acids showed a correlation between the number of double bonds in the fatty acids and their effect on the blood total cholesterol, phospholipids and total lipids. On the other hand, Keys *et al.* (1959a) reported that the feeding of essential arachidonic acid containing four double bonds did not cause a decrease in the serum cholesterol.

Keys *et al.* (1957a, 1957b, 1959b) and Anderson *et al.* (1957a) concluded that neither the general unsaturation degree of fats nor their linoleic acid content alone could fully explain the

changes observed in the serum cholesterol. In their opinion, only poly-unsaturated fats reduce the serum cholesterol, whereas mono-ethenoids are hardly of significance in this respect. Based on their observations they presented an equation according to which one gramme of saturated acids raises the serum cholesterol approximately twice as much as one gramme of poly-unsaturated acids reduces it. Since publishing these observations, members of their working group have reported, however, that this equation is not fully valid in the case of coconut oil (Keys *et al.* 1957 c) and corn oil (Grande *et al.* 1958).

Ahrens *et al.* (1957) have emphasized that, in addition to being highly saturated, butter and coconut oil differ from the other examined fats also in containing a large amount of short-chain fatty acids. The authors suggested that these short-chain fatty acids may raise the serum lipid level also for reasons other than their degree of saturation. Keys *et al.* (1957c) have presented a similar theory with respect to coconut oil.

Phytosterols

In addition to fatty acid triglycerides, vegetable fats contain also phytosterols, in analogy to the cholesterol in animal fats. Among the phytosterols, considerable attention has been paid to β-sitosterol, which is present in large amounts in, for example, corn oil. It has been observed that the addition of β-sitosterol to the diet is accompanied by a reduction in the serum cholesterol (Pollak 1953, Best *et al.* 1954, 1955, Joyner and Kuo 1955, Best and Duncan 1956, Farquhar *et al.* 1956, Sachs and Weston 1956). On the other hand, Kalliomäki *et al.* (1957), and Riley and Steiner (1957) obtained inconsistent results and Wilkinson *et al.* (1955) observed no change. Weiner *et al.* (1958) found a reduction in S_f 0—20 lipoproteins but not in serum cholesterol when β-sitosterol was added to a low-fat diet. The dosages of β-sitosterol used in the above mentioned studies, however, were considerably larger than the amounts contained in the »normal» human diet.

Beveridge *et al.* (1958) reported that a fraction of corn oil separated by vacuum distillation and containing a large amount

of sitosterol has the same lowering effect on plasma cholesterol as corn oil *per se*. They concluded that sitosterol or something closely associated with this sterol in the unsaponifiable fraction is responsible for the cholesterol-depressing effect of corn oil. Farquhar and Sokolow (1958) observed that the serum cholesterol, phospholipids and β-cholesterol decreased by an equal amount when β-sitosterol or safflower oil were given separately, whereas the levels were reduced further when the two substances were given at the same time. In the opinion of the authors, the action of the safflower oil is probably not due to the small amount of sitosterol which it contains, and that the decreasing agents on the serum lipids are both β-sitosterol and unsaturated fatty acids. Grande *et al.* (1958) stated that the unsaponifiable fraction of corn oil containing sitosterols may enhance the serum cholesterol-depressing effect of unsaturated fatty acids in this oil. On the other hand, Ahrens *et al.* (1957) reported that the unsaponifiable fraction of corn oil containing a large amount of phytosterols did not enhance the reduction produced in the serum cholesterol and phospholipids by the fatty acid fraction of corn oil.

Total Calories

A number of investigators have pointed out the occurrence of low serum cholesterol levels during World Wars I and II (e.g., Rosenthal and Patrzek 1919, Brull 1945, Roch and Besser 1946, Schmidt-Thomé *et al.* 1948, and Schettler 1950). During these periods the diet was unusually low in calorie value and in fats.

It has been observed that a high carbohydrate-low calorie diet produces a decrease in the plasma cholesterol in diabetic patients (Rabinowitch 1935) and in over-weight patients (Walker and Wier 1951). Keys *et al.* (1950a) also observed a fall in the serum cholesterol level in young normal-weight men kept on a weight-reducing low-fat diet. On the other hand, Poindexter and Bruger (1935) failed to note any alteration in the cholesterol content of the plasma in obese patients during a low-fat diet. Pomeranze *et al.* (1952) noted that a rigid fat

restriction in the diet without reduction in body weight caused a fall in the serum cholesterol, phospholipids and total fat content, whereas weight reduction without marked fat restriction in the diet did not depress these serum lipids in obese patients. Young *et al.* (1953) and Moore *et al.* (1954) found that weight reduction was associated with an increasing trend in the serum cholesterol level in over-weight women, whereas a tendency to decrease was seen in over-weight men (Moore *et al.* 1955).

In association with changes in body weight a varying trend has been observed in the different lipoprotein fractions. A reduction in the S_f 12—100 lipoproteins was obtained with a reducing low-fat diet, whereas they increased with increasing weight even when the diet was low in fat (Walker *et al.* 1953). The S_f 20—400 fraction was lowered by a weight-reducing diet rich in animal fat, while the S_f 0—12 lipoproteins increased with an increasing dietary fat intake, apparently independent of weight change (Walker *et al.* 1957).

Mann *et al.* (1955c) found no elevation of the serum cholesterol and lipoproteins when the calorie supply was doubled by additional carbohydrates, as long as activity was increased correspondingly. Anderson *et al.* (1957b), without changing the activity, raised the calorie content of the diet so that the proportion of calories from fats fell slightly and observed a rise in the serum cholesterol and S_f 12—20 lipoproteins during increasing weight.

Some Other Factors

Few investigations have been made of the effect of *carbohydrates* on the serum lipids in man. Ahrens (1957) mentioned that the exchange of sucrose, dextrose and dextrin in the diet produced no change in the serum lipids. Hatch *et al.* (1955) observed that a rice diet rich in carbohydrates raised the neutral fat content of the serum. Likewise, Ahrens *et al.* (1957) and Kinsell *et al.* (1958) found an increase in the serum triglycerides and Nichols *et al.* (1957) in the serum $S_f°$ 20—400 lipoproteins during a carbohydrate-rich diet.

Information on the effect of dietary *protein* on the serum

lipids in man are limited almost entirely to the amount of proteins. Keys and Anderson (1957) doubled the supply of dietary proteins without observing an effect on the serum cholesterol level. According to Bronte-Stewart *et al.* (1956), also, an increase in the dietary protein had no effect on the serum cholesterol or the β-cholesterol. Albanese *et al.* (1959) found inconsistent effects on plasma cholesterol after the addition of milk proteins to the diet. Olson *et al.* (1958), on the contrary, observed a decrease in the serum cholesterol during a period of low-protein feeding, and Furman *et al.* (1958) found a reduction in the serum cholesterol and phospholipids when milk protein was isocalorically replaced by glucose.

Amino acids have been found to influence the serum lipids of experimental animals (Mann *et al.* 1953a, Fillois and Mann 1954) but their effect on human serum lipids has been a subject of meager investigation. However, Mann *et al.* (1953b) stated that the addition of methionine to the diet did not alter the serum lipid levels in man.

The effect of certain *vitamins* on human serum lipids has also been studied. Beveridge *et al.* (1957) failed to find any effect by the α-tocopherol of corn oil on the serum cholesterol, and Gray and Loh (1958) observed that α-tocopheryl acetate caused an increase in the plasma cholesterol and phospholipids. The level of serum cholesterol has been found to be lowered by supplements of nicotinic acid (Altschul *et al.* 1955, Parsons *et al.* 1956, Parsons and Flinn 1957, 1959, O'Reilly *et al.* 1957, Achor *et al.* 1958, Galbraith *et al.* 1959). The addition of pyridoxine to the diet was observed by Failey (1958) to depress the serum cholesterol. However, the vitamin supplements in the diets were given in such large doses that their effect was pharmacological rather than dietary.

Summary of Dietary Effects on Blood Lipids in Man

Opinions concerning the influence of nutritional factors on human serum lipids have varied greatly at different times. At the present stage of investigation it appears that the cholesterol

content of the diet has no effect on the serum lipids in man. The amount of dietary fat does not alone influence the serum lipids, the effect being at the same time dependent on the type of fat. A number of vegetable and marine oils containing highly unsaturated fatty acids have been found to depress the serum lipid level, in contrast to highly saturated animal fats. Numerous investigators have suggested that the sitosterol in vegetable oils may also contribute to the reduction in serum lipids, and some investigators have emphasized in this respect also the rôle of the fatty acid chain lengths of dietary fats.

The effect of dietary carbohydrates and proteins on the human serum lipids has been little studied. On the basis of the few investigations made it would seem that carbohydrates may possibly produce an increase in the neutral fats in serum, but the results concerning the effect of dietary proteins are controversial. Observations concerning the influence of the total calorie amount on the human serum lipids are inconsistent.

PHYSICAL ACTIVITY AND BLOOD LIPIDS

The earliest investigations on the effect of physical activity on the lipids in human blood were carried out in connection with short-period experiments. Rakestraw (1921) noted that the blood cholesterol was unaffected by severe muscular exercise. Fahrig and Wacker (1932), on the contrary, observed a rise in the serum cholesterol and lipid phosphorus immediately after physical exertion, while Patterson (1927) and Stewart *et al.* (1931) found no change in the blood cholesterol but a transient rise in the blood total fat concentration. Gage and Fish (1924) noted an increase in the fat particles in the blood. A transitory fall in the blood cholesterol was found by Robinson *et al.* (1927). In animal experiments of short-time physical exercise Hiramatsu (1932) observed no change in the blood total lipids in rats kept before the experiment on a rice diet, but there was a fall when they were kept on a meat diet. An increase in the serum cholesterol and phospholipids was observed by Amelotti (1955) in rats after swimming but this increase was not noted when the animals were made to swim up to exhaustion.

It was reported by Iakovlev (1952) and Mnukhina (1955) that in runners, and by Iakovlev *et al.* (1952) that in members of ball teams the serum phospholipids were lower after a sports contest than before it. However, Karvonen *et al.* (1958) observed no change in the serum total cholesterol in champion skiers after a contest, nor did Beischer (1956) find the serum cholesterol, phospholipids or lipoproteins change after sudden physical exercise. Keys *et al.* (1956b) noted a higher serum cholesterol level after a meal in persons who were at rest than in persons performing physical work.

In the short-time experiments mentioned above the serum lipid level appears to depend on, for example, how soon after the exercise the blood sample is taken (Robinson *et al.* 1927), the amount of exertion (Iakovlev *et al.* 1952) and the duration of the exercise (Stewart *et al.* 1931, Iakovlev 1952, Mnukhina 1955). On the other hand, in short-period exercise the results may also be influenced by which muscle group is exerted, as was suggested by Iakovlev *et al.* (1952). Cholesterol from the body's own fat stores may also be mobilized into the blood circulation during acute exercise, as was demonstrated by Somogyi (1939) in experiments with cats.

In studying the serum cholesterol levels in subjects classified by occupation, Keys *et al.* (1955b, 1956a) observed that persons doing heavy physical work appear to have a lower serum cholesterol level than persons engaged in light work. However, in their opinion other factors associated with the occupation, especially food, has a much greater influence on the serum cholesterol than activity. Likewise, Brunner and Lobl (1958) found that professional workers had a higher β-cholesterol level than manual workers. It has been suggested that the low serum cholesterol values in the natives of Guatemala (Mann *et al.* 1955a) and of Nigeria (Mann *et al.* 1955b), as compared with those seen in North America, may be due to the difference in the diet and physical activity in these regions, since a difference was seen only in the serum total cholesterol but not in β-lipoproteins. Studies by Gopalan and Ramanathan (1957) revealed a higher level of blood cholesterol in officers in the Indian army than in army personnel of other ranks. Since the diet in both groups

was very similar, the authors ascribed the low cholesterol level of the other ranks to their greater physical activity. Keys *et al.* (1958b), in their study of a male population in Finland aged 40—49 years, observed a lower serum cholesterol level in persons performing heavy physical work than in those doing lighter work. In younger and older groups, however, no difference was seen in this respect. Karvonen *et al.* (1958) found in Finnish champion skiers a lower serum cholesterol level than that seen in a Finnish rural population of the same age.

The effect of long-time exercise on the serum lipids has been studied in animal experiments. Peltonen and Karvonen (1956) observed no definite decrease in the plasma cholesterol when mice were exercised by making them swim in water on nine days. Likewise, Wong *et al.* (1956) reported that exercise during experiments lasting eight weeks did not reduce the blood cholesterol level of cockerels. Similar results were obtained by Mayer *et al.* (1957) with mice during an experimental period of one month and by Kobernick *et al.* (1957) and Brainard (1959) with rabbits exercised for two months. It has been reported that physical exercise during three months (Brown *et al.* 1956) and during six months (Kipshidze 1958) inhibited in rabbits the hypercholesteremia produced by feeding cholesterol, which was seen in the control groups. Orma (1957) noted that the normal activity of cockerels inhibited, in contrast to complete inactivity, the increase in the serum cholesterol, phospholipids and α- and β-cholesterol produced by feeding cholesterol. The difference in activity, however, had no influence in connection with normal feeding. In connection with cholesterol feeding Wong *et al.* (1957) observed a smaller rise in the blood cholesterol of cockerels and Schlüssel *et al.* (1959) of guinea pigs forced to run than in animals without exercise.

There is very little information on the effect of long-period activity on human serum lipids. Chailley-Bert *et al.* (1955) found in three sedentary, hypercholesteremic subjects a decrease in the serum cholesterol after they began to exercise. No information was given of the diet of these subjects during this time, however. In four weeks' experiments with three students, Mann *et al.* (1955c) demonstrated that doubling the calorie supply

with carbohydrates did not increase the serum cholesterol or lipoproteins as long as activity was increased correspondingly. When, on the contrary, the activity was not increased during such a high-calorie period, the serum lipid levels increased in two of the three subjects studied.

Taylor *et al.* (1957) have published the results of a study of the serum lipids in nine students during physical exercise. The subjects' normal physical activity was increased by treadmill walking for two hours daily during two weeks. During the exercise period the proportion of fat calories in the diet was maintained unchanged from that during the control periods; the total calories were increased in proportion to the exercise. No change was seen in the serum cholesterol and the β-cholesterol, whereas the phospholipids decreased during the period of activity. Taylor (1958) expressed the conclusion that exercise allows a man to handle a large increase in dietary fat without a comparable increase in serum cholesterol. Schlesinger (1958) observed an increase in the serum cholesterol and S_f^o 20—400 lipoproteins during the eight-week basic training period of draftees in the United States army. A decrease, on the contrary, was seen in S_f^o 0—12 and S_f^o 12—20 lipoproteins, and the changes in the lipid phosphorus were not consistent. The physical activity was severe, but the food was rich in fats and the mean body weight of the men increased during this period. Montoye *et al.* (1959) found no change in the serum cholesterol of middle-aged men when the physical exercise was increased by two or three hours weekly during three months.

Summary of the Effect of Physical Activity on Blood Lipids

The results reported in the literature on the effect of short-time exercise on the serum lipids are contradictory. On the basis of animal experiments, physical activity during a longer period does not seem to influence the serum lipids, except possibly in association with the feeding of cholesterol.

Attempts have been made to elucidate the effect of long-time physical activity on the human serum lipids by comparative studies of occupational groups differing in physical activity. On

the basis of these studies it would appear probable that persons in physically heavy occupations exhibit a lower level of serum cholesterol than those engaged in light work, but the contribution of other factors possibly allied with such occupations is difficult to define. The results are contradictory in the few investigations in which the daily physical activity of the test subjects was increased.

OBJECT OF THE PRESENT INVESTIGATION

The possibilities to study the influence of long-period physical activity on the serum lipids in man are limited under normal living conditions. An opportunity for studies of this kind is available in soldiers during military service, when men are undergoing training that involves different degrees of physical activity. Fairly detailed data are available on the composition of the diet during military training, and it is also possible to estimate the amount of physical activity required in the different types of training.

The present investigation was undertaken with the purpose of studying whether changes occur in the serum lipids of young men during military service and how such changes, if they occur, are explicable. It was considered to be of particular interest to study whether a difference was observable in the serum lipid in men undergoing physically heavy training and in those undergoing light training.

MATERIAL

The series consisted of 187 healthy men enrolled in the Finnish army for their compulsory military service. The mean age of the men on entering the service was 19.9 years (range 18—26 years).

Male citizens of Finland are selected for the compulsory military service on the basis of a draft board examination made during the year preceding entry into service. The men are classified on the basis of a medical examination then performed and those in good health are ordered into the service, while men who are or are suspected to be affected with a disease or deformity are exempted from service. The men assigned for military service are classified into A and B classes. Those selected for the A class (A-men) are approved for armed service at the front, and their training during the compulsory service period is directed towards giving them a pertinent training. Into class B (B-men) are assigned the men whose combat fitness is limited by constitution, physical disability or physical weakness to such an extent that they cannot be ordered to serve in armed frontline units. During their military service period the B-men are given training in fatigue duties.

In the draft board examination a qualification record and a medical examination card are filled out for each man. The qualification record states the examinee's personal data, including education, and information on courses attended and on hobbies. The medical examination card contains the information given by the draft board's physician on the state of health of the examinee, a record of previous major illnesses, data on body length and weight, and other pertinent information.

In Finland the military service period is 240 days for privates and 330 days for non-commissioned officers and for those to be trained for reserve officers. In ground forces the men enter

the service three times a year at intervals of four months, i.e., on the following dates:

Contingent	I	February 15
»	II	June 15
»	III	October 15

For the present investigation an approximately equal number of men were selected from each of the three contingents which arrived for military service in 1957. In selecting the men an effort was made to obtain groups that were as dissimilar as possible in physical activity. For this reason one-half of the subjects were selected from A-men receiving a heavy infantry training and the other half from B-men receiving instruction in light fatigue duties. Furthermore it was considered desirable to have the groups of A- and B-men composed of an equal number of persons who in their civilian occupation performed heavy and light physical work. As great similarity of age as possible was also considered important. Persons whose relative body weight was 35 per cent above or below the ideal body weight in the Metropolitan Life Insurance Co.'s (1943) tables were excluded.

The men were selected on basis of the qualification records and the medical examination cards. A total of 276 men were originally selected for investigation, but in the course of the study it was necessary to reject about one-third of them for reasons to be presented later.

High active men = A-men. These men were selected from an infantry battalion stationed near the city of Helsinki. Training in this battalion is physically very strenuous. It includes a large amount of hard physical exercise, such as marches and field and combat training. Originally 135 men were selected from this battalion. They were residents of Helsinki, its vicinity, and south-west Finland.

Low active men = B-men. These were selected from a unit stationed in the city of Helsinki. A special fatigue duty company in this garrison is composed of men from different regions of Finland. Those approved for the present investigation had been ordered for fatigue duty training because of hyperopia or myopia, unilateral blindness, defective hearing, postural

fault in an extremity, handicapping scars, faulty posture of the spine, thorax deformity, missing fingers, habitual luxation of a joint, post-osteomyelitic conditions, slight mental debility, and conditions following pleuritis and glandular or pulmonary tuberculosis. Originally 141 B-men were selected.

Both A and B groups consisted of men who by civilian occupation were sedentary workers and laborers. The sedentary workers represented occupations that were known to require only little physical exertion. Assurance was also obtained that they had not been active in sports requiring much physical exercise. The sedentary workers who were approved for investigation were students, engineers, architects, physicians, chemists, teachers, and office workers. The approved laborers had a civilian occupation involving heavy labor, and were forest, farm, construction and harbor workers. Many of them, in addition, had been active in sports.

With the exception of sedentary workers for the B group, all the contingents contained a large number of men conforming to the above criteria. The desired number of B-sedentary workers was not found in any of the contingents. More men were therefore selected for the B-laborer subgroup, since it was considered important to have the same total number of men in the A and B groups.

Since possible differences in the criteria used by different draft board physicians might have caused inconsistencies in the selection of the men, all the medical examination cards were checked by re-examination of the men after the physician of the unit had performed the primary medical examination on the arrival of the men into service. The primary examination included, in addition to a general physical examination, the mass x-ray of the chest, measurement of the blood pressure, and qualitative determination of albumin and glucose in the urine. If there was a difference in the findings in the medical examinations, or if there was other reason to suspect the presence of a disease, the subject was not approved for inclusion in the investigation series.

Some men were immediately rejected on basis of the medical re-examination because of a disease. In some cases there was a transient disease at the time of taking of a blood sample, or

the sedimentation rate was elevated, which in itself was a reason for rejection. A reduced blood hemoglobin was the reason for rejection in some cases; the lowest permissible limit was 12.8 g per 100 ml. A few men were lost by transfer to other units. Some were also rejected after being commanded for kitchen service, where food was available to them in proportions different from those of the other investigated men.

Only the men who were present at all of the four blood tests are included in the present series. The total number of these men was 187. They were distributed into subgroups, as follows:

A-men, total 94 men { A-sedentary workers, 51 men; A-laborers, 43 men

B-men, total 93 men { B-sedentary workers, 30 men; B-laborers, 63 men.

DIET DURING MILITARY SERVICE

With the exception of a few days at the maneuvers, the conscripts take their meals together in the messhall of the unit. The food is prepared and served according to a previously calculated food consumption program, which is drawn up for two-week periods, separately for the summer and winter seasons. The list of foods prepared according to this program is repeated almost without change at intervals of two weeks. The daily diet is maintained very similar with regard to the amount of calories and the principal sources of energy. The meals are served at the following hours: breakfast, 7 a.m., lunch, 11 a.m., and dinner, 5 p.m. Tea is served on three evenings a week.

The ration calculations of both investigated units and of the reserve officers' school, which is separate from the units, during summer and winter seasons were made available to the present writer. In order to ascertain that the food in the units actually was consumed according to the ration calculations, a dietary study was carried out during two weeks in March 1958 and during one week in August 1958. The items used in the preparation of the food for the total strength of the unit were carefully weighed during the dietary study weeks. Knowing the number

of men present at each meal, it was possible to calculate the mean amounts of food items served daily per man.

The men in the units concerned have an opportunity, in addition to the meals served at table, to procure food only in the garrison's club cafeteria and in packages received from home. A close inquiry was also made concerning the food obtained by the men in this manner (Konttinen and Roine, to be published).

To determine the exact amounts of different foods consumed by the men, also the plate and kitchen waste was weighed in each dietary study. The difference between the amounts served, purchased in the club cafeteria, received in packages from home, and those discarded as waste are the amounts of nutrients actually consumed (table 1).

TABLE 1

Average Daily Consumption of Proteins, Fats, Carbohydrates and Calories per Man in Summer and Winter in Two Military Units from Which the Men Were Selected

	Unit from Which A-Men Were Selected		Unit from Which B-Men Were Selected	
	Summer	Winter	Summer	Winter
Proteins (g)	147.0	139.8	122.3	126.4
Fats (g)	146.5	145.8	127.7	132.2
Carbohydrates (g)	627.9	629.3	607.2	615.6
Total Energy (kcal)	4 352	4 299	4 012	4 063
Energy from Proteins (%)	13.5	13.0	12.2	12.5
Energy from Fats (%)	30.3	30.5	28.7	29.3
Energy from Carbohydrates (%)	56.2	56.5	59.1	58.2

The mean total energy and the mean amounts of fat, protein and carbohydrates consumed daily per man were calculated according to the Finnish food consumption tables of Turpeinen and Roine (1952). A comparison of the values obtained in the dietary study with the ration calculations used in the units showed that they were very similar. At the time of the dietary studies in both winter and summer, men from two contingents were simultaneously in service. The two contingents may consume different amounts of energy, depending on the physical exertion demanded by the training phase then in progress. However, the same training phases were represented in the dietary studies carried out in winter and in summer, and the observations

TABLE 2

Average Daily Consumption of Lipids per Man in Summer and Winter in Two Military Units from Which the Men Were Selected

	Unit from Which A-Men Were Selected		Unit from Which B-Men Were Selected	
	Summer	Winter	Summer	Winter
Fatty Acids				
Saturated (g)	80.4	80.6	70.0	72.2
Mono-ethenoids (g)	47.1	46.8	49.9	43.3
Linoleic (g)	10.4	9.8	9.4	9.4
Other Poly-ethenoids (g)	1.8	1.4	1.2	1.1
Ratio of Saturated/Linoleic + Poly-ethenoids	6.6	7.2	6.7	6.8
Animal Fats (g)	109.6	103.9	91.9	99.7
Vegetable Fats (g)	36.9	41.9	35.8	32.5

during the two seasons are therefore comparable in this respect. Furthermore, it is to be observed that in the unit in which the B-men were serving about one-half of the total strength were A-men, whose training is nearly as severe as that of the A-men in the present investigation. According to the observations of the supply service officials of the unit, B-men consume less food than A-men. On the other hand, it is to be noted that owing to the manner of serving the meals in the armed forces the men have very little opportunity to select their food even when the consumption of total energy may vary. Obviously the present dietary study is not comparable with more thoroughly controlled dietary studies, but it may nevertheless be considered probable that it gives a comparatively reliable picture of the proportionate amounts of different foods consumed also individually.

The mean daily consumption of saturated fatty acids, mono-ethenoids, linoleic acid and other poly-ethenoids was calculated from the food actually consumed (table 2). After the glycerol residue was deducted from the total amount of the fat content the calculations were made with the aid of the percentages of different fatty acids in foods prepared by A. Keys and reported by Pekkarinen (1958). In calculations of fatty acids in butter fat there were used the Finnish mean values calculated by Pekkarinen (1958) from the values published by Peltola (1944). The fatty acids in Finnish margarine were obtained from analyses made in the United States and reported by Pekkarinen (1958).

PHYSICAL ACTIVITY DURING MILITARY SERVICE

Training in the Finnish army begins daily at 7.30 a.m. and ends at 5.00 p.m. At noon there is a recess of about one hour for lunch. The men are trained according to a weekly program drawn up under a training plan. The training plan, which is similar for all the contingents, prescribes with the accuracy of an hour the training to be given to the men undergoing each form of training. It also states the number of hours to be assigned for lectures and exercises. There is a separate training plan for A-men and B-men. The non-commissioned officers' school and the reserve officers' school have special training plans.

The training of A-men who are to be trained for non-commissioned officers' or reserve officers' rank differs greatly from that of privates after the basic training period. They then enter the non-commissioned officers' school, which they attend for 16 weeks. Pupils of the non-commissioned officers' school who have graduated from the intermediary grades of a secondary school or preferably have passed a university matriculation examination and have had a good ranking in the non-commissioned officers' school are commanded thereafter to attend the reserve officers' school lasting 14 weeks. The B-men are only given a basic training course for 7 weeks, after which they are commanded to various light duties, such as guard duty, office work, and so on. They do not receive non-commissioned or reserve officer's training.

In order to obtain an idea of the severity of the training during military service, the weekly average number of hours of training involving a large amount of physical exercise in the weekly training program was calculated separately for each training phase in the units in which the present investigation was carried out. The officer in charge of the training in each of the two units gave information on the forms of training to be included in the calculations. These were the following: marching, skiing, combat and field training, orientation, and close-order drill.

The training of the A-men included 20 hours of training types which required much physical exercise during the basic

training period (first eight weeks) and 15 hours thereafter. The men in the A-laborer subgroup in the present series were given this training.

The number of training hours of a type requiring much physical exercise was 27 hours per week in the non-commissioned officers' school and 30 hours per week in the reserve officers' school. After the basic training period all the A-sedentary workers in the present series were attending the non-commissioned officers' school and thereafter, with five exceptions, the reserve officers' school.

B-men had 9 hours per week of training forms requiring physical exercise during their seven weeks of basic training, and 3 hours per week thereafter.

The instruction officer informed the general principles of the severity of the different forms of training. Because of the short time of service in Finland, the training of A-men is a very tight one and the daily schedule includes much physical training of various kinds. Furthermore, the exercises for promotion of their physical fitness have intentionally been made extremely strenuous.

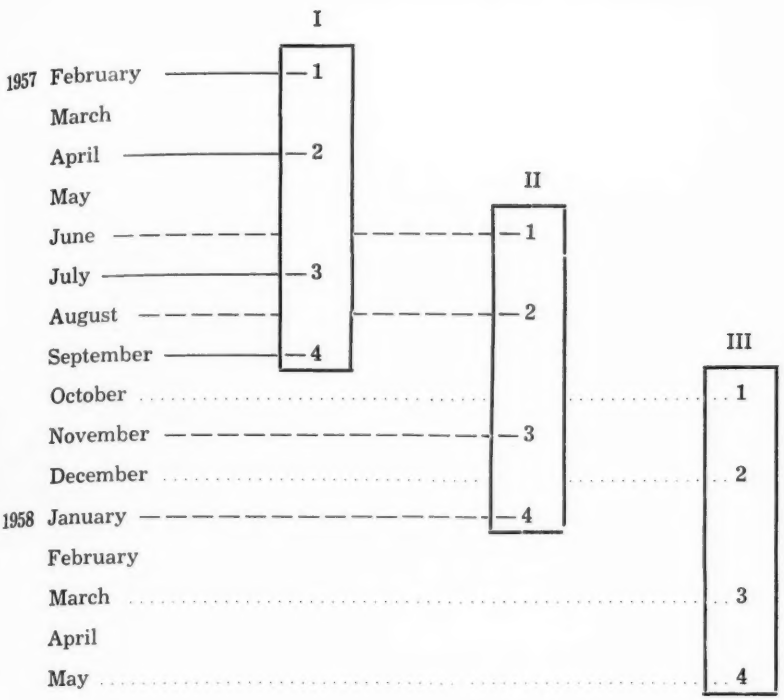
The training plan of the B-men is light in consideration of their physical defects. There is little physical training and it is very light. The purpose of the basic training, to which their physical exercise is limited, is to give the men a knowledge of disciplinary rules and of the use of weapons. They have only a nominal amount of actual combat training, and even this is light.

METHODS

ARRANGEMENT OF THE INVESTIGATION

For the lipid analyses, blood samples of about 10 ml were drawn from the cubital vein between 6.00 and 7.00 a.m., while the men were on a fasting stomach. The samples for the blood hemoglobin and the erythrocyte sedimentation rate were then taken through the same needle. The tubes containing blood were allowed to stand until a clot had formed, and were then transported with care to the laboratory. The blood was centrifuged two or three times until a clear serum separated. If hemolysis occurred, the sample was discarded and a new sample was drawn on the following morning. The height and weight of the men were also measured at each sample taking.

Four blood samples were taken from each subject. The first sample was taken during the first 3 days after arrival into military service, the second at the end of the basic training period of 8 weeks, the third 20 weeks after arrival, and the fourth after 32 weeks of service. The calendar months during which the samples were taken are shown below for each of the contingents I, II and III. The Arabic numerals state the sample numbers.



CHEMICAL METHODS

Determinations were made of the serum total cholesterol and total phospholipids, and of the distribution of these lipids in α- and β-lipoprotein fractions. The blood hemoglobin and the erythrocyte sedimentation rate were also determined at each sampling.

The total cholesterol was determined by slightly modifying the Anderson and Keys (1956) procedure of the method of Abell *et al.* (1952). On the day of sample taking the serum (0.1 ml) was absorbed on Whatman No. 1 filter paper, which was allowed to dry at room temperature. The dried samples were stored in a dark, dry place until analyzed about two weeks later. The stability of the cholesterol in the filter paper was controlled by several analyses, which showed that it remained unchanged for at least two months, as has been reported by Anderson and Keys.

Hydrolysis of the cholesterol esters was carried out in a thermostat at 70° C for 90 minutes and the cholesterol was extracted with petroleum ether (B.P. 40—60° C) by shaking for 60 seconds three times. The colorimetric reading was made at wavelength 625 $m\mu$ with a Beckman B photometer 35 minutes after the addition of Liebermann—Burchard reagent. The color reaction occurred in a water bath at 25° C.

The development of the color reaction was examined by several analyses made at 1 minute intervals during 20—45 minutes. It was found that the color maximum developed 32—38 minutes after addition of the reagent, usually at 35 minutes. Even when the maximum occurred 1—3 minutes earlier or later, the difference from the value obtained at 35 minutes was smaller than the methodical error.

The lipid phosphorus was determined, after ashing the ethanol-ether filtrates, by the method of Fiske and Subbarow (1925) as described by Nikkilä (1953). The ethanol-ether extraction was always begun on the day of sample taking. The optical density was measured in 5 cm cuvettes at 660 $m\mu$ with the Beckman B photometer. Factor 25.0 was used to convert the lipid phosphorus values to those of phospholipids.

Fractionation of the lipoproteins was done by means of paper electrophoresis. The construction of the electrophoresis apparatus and the performance of the runs were based on the method of Nikkilä (1953), with slight modifications. Whatman No. 1 filter paper was cut into sheets 12 by 30 cm and 0.15 ml of serum was pipetted on each sheet. Barbiturate buffer, pH 8.6, was used. Time of run was ca. 3 hours, and as three apparatuses were available all the electrophoretic runs were, with a few exceptions, completed not later than on the day following the taking of the blood samples. The sera were stored in the refrigerator at + 4° C until analyzed.

After the run was completed the electrophoresis sheets were allowed to dry in a horizontal position on a drying rack at room temperature. To localize the lipoproteins a piece 2.5 cm in width was cut from one long edge of each sheet and stained with Sudan black B according to the method of Swahn (1953) (fig. 1). The unstained sheets were then cut into strips of α- and β-lipo-

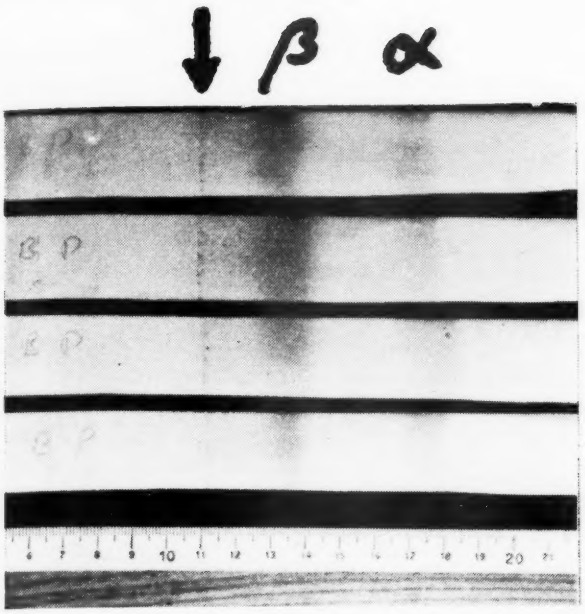


Fig. 1. Sections from electrophoretic runs stained with Sudan black. Arrow shows the starting line. Below the figure tape in cm.

proteins with the aid of the staining and of the fluorescence of the albumin band in ultraviolet light, as described by Miettinen (1956). For the purpose of control, the proteins were also stained in a few cases with bromphenol blue by the method of Durrum (1950).

The cholesterol in the α- and β-lipoprotein fractions was determined from the cut strips in the same manner as the total cholesterol. The corresponding phospholipid determinations were performed by the method described by Nikkilä (1953). The readings of cholesterol and phospholipids in the α- and β-lipoprotein fractions were relative values, for which the absolute amounts were obtained by calculation from the total amount of the corresponding lipid.

For the hemoglobin determination, 0.025 ml of blood was taken into a tube containing 10 ml of 0.04 per cent ammonia-water solution. The reading was performed in a Hilger spectrophotometer with filter No. 55 against a blank of distilled water. The hemoglobin value in grams per 100 ml was obtained from

tables used in the laboratory. The sedimentation rate of one hour was determined by the method of Westergren.

All the lipid determinations and electrophoretic runs were carried out by the writer.

STATISTICAL METHODS

Methodical Error. — The methodical error was calculated on the basis of double determinations. The following methodical errors *(s)* were found in the various lipid determinations, *n* being the number of pairs of observations made:

Lipid	*n*	*s*
Total cholesterol	123	3.7
β-cholesterol	91	2.4
Total phospholipids	122	3.9
β-phospholipids	83	2.9

From the observed value of the methodical error it may be concluded that in a single determination the methodical error may be twice as large as the methodical error. In other words, a double methodical error indicates the most probable range of random variations (upper limit of 95 per cent confidence limit).

Statistical Characteristics. — The means and standard errors of the mean were calculated by the usual methods described in any competent textbook on statistical methods. In tabulations of the results, the mean and the standard error of the mean are stated.

Comparison of the Series. — To determine the statistical significance of the differences between the examined groups, the t-test, analysis of variance, or regression analysis were applied, depending on the question under analysis. The »Student's» t-test was applied to the difference between the means of two groups. When the significance of the difference between three means was studied, the classical analysis of variance was applied. In the regression analyses the method of least squares was applied. The significance of the regression was examined by the variance ratio (v^2) test.

The degree of statistical significance is expressed as P, the

value of which indicates the degree of probability with which the observed difference (or differences) is due to chance only. $P < 0.001$ designates a highly significant difference between the examined groups, $P < 0.01$ a significant difference, and $P < 0.05$ an almost significant difference. Where the difference could not be ascribed any statistical significance, the P value is indicated by two dots (..).

RESULTS

SERUM LIPIDS IN THE TOTAL SERIES

The curves for the mean values of serum lipids in the total series of 187 soldiers at each of the four determinations are shown in fig. 2. The mean values and standard errors of the mean are presented in table 18 in the Appendix.

The serum total cholesterol level decreased during the basic training period of eight weeks (between the first and second determinations) from 208.8 mg per cent to 188.1 mg per cent. This fall is highly significant ($P < 0.001$), as is shown in table 3a. At the later determinations the total cholesterol remained at this lower level. Fig. 2 shows that the changes in the β-lipoprotein cholesterol appear to be parallel to the changes in the total cholesterol. Nearly three-fourths of the total amount of cholesterol in the serum was present in the β-lipoprotein fraction at every determination. The α-lipoprotein cholesterol, on the other hand, decreased at each determination, as is seen in fig. 2. The decrease in the cholesterol in this fraction during the whole period of investigation, from 56.0 mg per cent to 46.7 mg per cent, is highly significant ($P < 0.001$), as seen in table 3b.

In the total phospholipids a reduction from 221.1 mg per cent to 208.2 mg per cent occurred during the basic training period. The decrease (table 3a) was also here — as in the total cholesterol — highly significant ($P < 0.001$). Between the second and third determinations the total phospholipid level increased significantly ($P < 0.01$) and it was still at this level at the last determination. As is seen in fig. 2, the changes in the phospholipids in the β-lipoprotein fraction appear to follow the changes in the total phospholipids. Slightly over one-half of the total phospholipids were present in this fraction in all the determinations. The phospholipids in the α-lipoproteins decreased at every determination, and the fall from 103.1 mg per cent to 97.5 mg

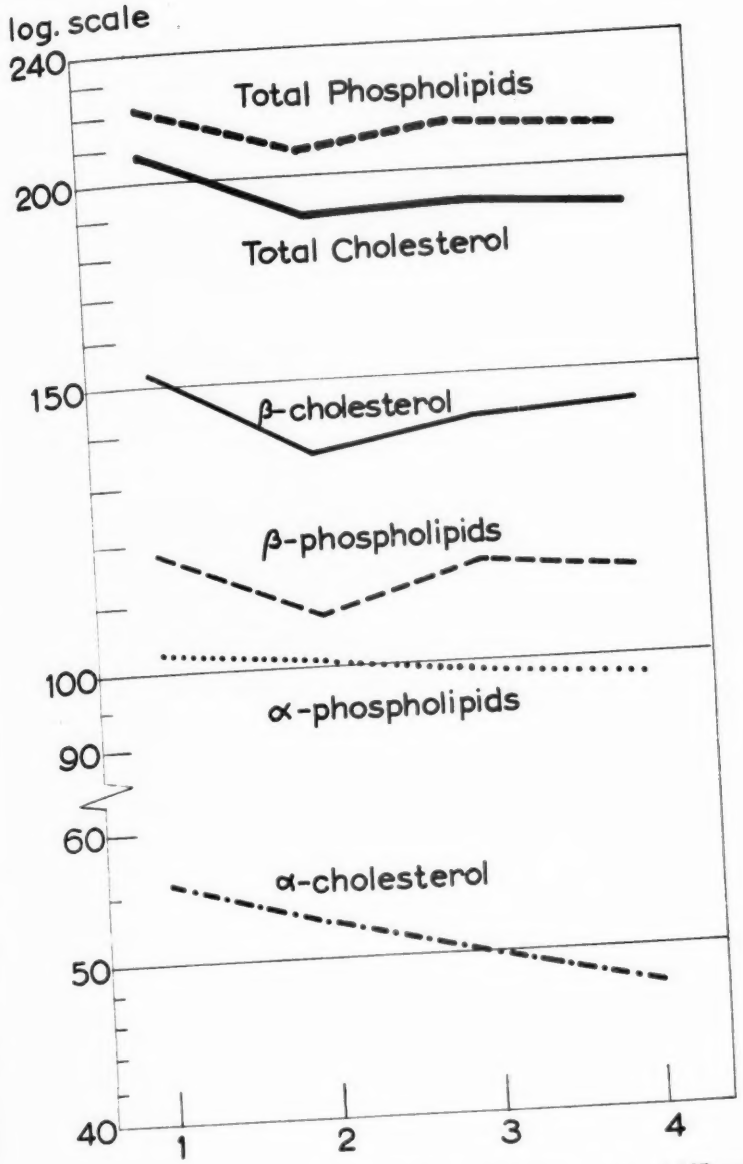


Fig. 2. Mean changes in the serum lipids in the total series of 187 men at different determinations during military service.

TABLE 3

a. Testing of Changes in Total Cholesterol and Total Phospholipids between Different Determinations in the Total Series of 187 Men: t-Test

	Between Determinations	Change	Standard Error of Change	t	P
Total Cholesterol	1—2	— 20.7	2.09	9.90	0.001
	2—3	+ 2.5	1.83	1.36	..
	3—4	— 1.6	1.99	0.75	..
Total Phospholipids	1—2	— 12.9	2.57	5.04	0.001
	2—3	+ 5.7	1.96	2.92	0.01
	3—4	— 3.3	2.03	1.61	..

b. Testing of Changes in α-Cholesterol and α-Phospholipids between First and Last Determinations in the Total Series of 187 Men: t-Test

	Change	Standard Error of Change	t	P
α-Cholesterol	— 9.3	0.76	12.20	0.001
α-Phospholipids	— 5.6	1.53	3.66	0.001

per cent during the whole investigation period was highly significant ($P < 0.001$, table 3b), in similarity to the cholesterol in the same lipoprotein fraction.

Table 4 shows the distribution of the men according to the change in the serum total cholesterol during the basic training period. A similar distribution according to the change in the total phospholipids is given in table 5. Values which at the end of the basic training period were $\leq \pm 9$ mg per cent of the initial values were regarded as unchanged (the methodical error was 3.7 for total cholesterol and 3.9 for total phospholipids). The greatest decrease seen during the basic training period in the total cholesterol was 115 mg per cent and the greatest increase was 62 mg per cent. The corresponding figures for the total phospholipids were 178 mg per cent and 86 mg per cent. Tables 4 and 5 reveal great individual variations in the change in the serum total cholesterol and total phospholipids during the basic training period. Several investigators, among others Kempner

TABLE 4

Change in Total Cholesterol during the Basic Training Period

	Number of Men
Fall 90 mg% or over	2
» 70—89 mg%	4
» 50—69 »	24
» 30—49 »	42
» 10—29 »	53
No Change ($\leq \pm 9$ mg%)	39
Rise 10—29 mg%	17
» 30—49 »	4
» 50—69 »	2
Total	187
Fall	125
No Change	39
Rise	23

TABLE 5

Change in Total Phospholipids during the Basic Training Period

	Number of Men
Fall 90 mg% or over	2
» 70—89 mg%	4
» 50—69 »	12
» 30—49 »	39
» 10—29 »	43
No Change ($\leq \pm 9$ mg%)	46
Rise 10—29 mg%	21
» 30—49 »	14
» 50—69 »	4
» 70—89 »	2
Total	187
Fall	100
No Change	46
Rise	41

(1948, 1949) and Starke (1950) found in their dietary experiments that the most marked drop in the serum total cholesterol occurred in subjects with initially high serum cholesterol. The dependence of the changes in the total cholesterol and total

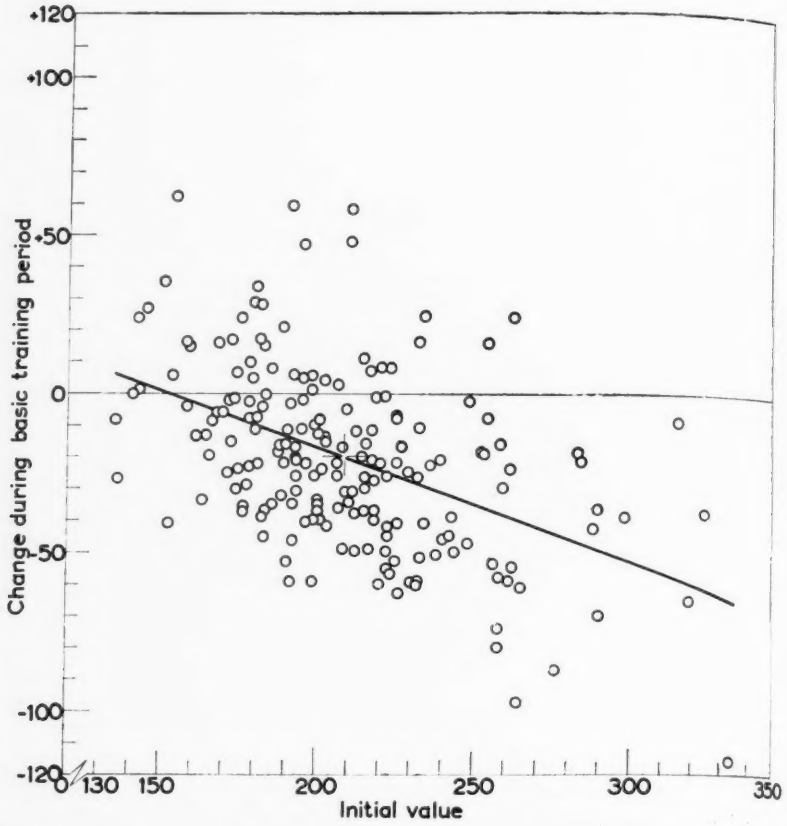


Fig. 3. Dependence of the change in total cholesterol during the basic training period on the initial value.

phospholipids on the respective initial values of these lipids is shown in figs. 3 and 4. The calculations of this dependence (table 6) show that the magnitude of the change in both the total cholesterol and the total phospholipids is highly significantly ($P < 0.001$) dependent on the initial value of the respective lipid.

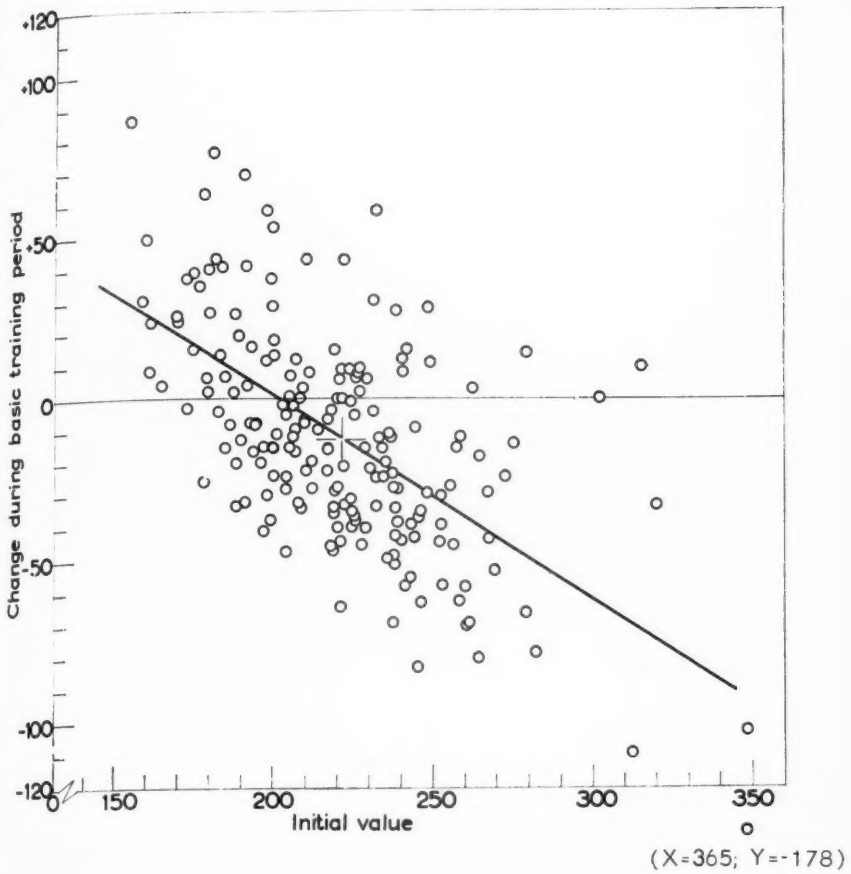


Fig. 4. Dependence of the change in total phospholipids during the basic training period on the initial value.

TABLE 6

Dependence of Changes in Total Cholesterol and Total Phospholipids during the Basic Training Period from the Respective Initial Values: Regression Analysis

x_0 = Change during the basic training period
x_1 = Initial value

		P
Total Cholesterol	$x_0 = 56.3 - 0.37x_1$	0.001
Total Phospholipids	$x_0 = 129.5 - 0.64x_1$	0.001

SERUM LIPIDS IN THE SERVICE CLASS GROUPS

Classified according to the training given to the men during military service, the investigated series consisted of 94 A-men receiving heavy infantry training and 93 B-men receiving light training in fatigue duty. The curves for the mean values of serum lipids in these service class groups at the different determinations are shown in figs. 5 and 6, and the mean values and standard errors of the mean are listed in table 19 in the Appendix.

At the beginning of military service there was no difference in the total cholesterol and total phospholipid levels in the two service class groups (table 7a).

It is seen from table 7b that the changes in the total cholesterol and total phospholipids were not statistically different in the A-men and B-men groups during the basic training period, when the changes in these lipids were greatest. Figs. 5 and 6 show that the changes in the cholesterol and phospholipids in the lipoprotein fractions also run parallel in the A-men and B-men groups during the basic training period.

TABLE 7

a. Testing of Differences in Total Cholesterol and Total Phospholipids between Service Class Groups of 94 A-men and 93 B-men at the Beginning of Military Service: t-Test

	Difference between Groups	Standard Error of Difference	t	P
Total Cholesterol	4.7	5.46	0.86	..
Total Phospholipids	4.7	4.95	0.95	..

b. Testing of Differences in Changes in Total Cholesterol and Total Phospholipids between Service Class Groups of 94 A-men and 93 B-men during the Basic Training Period: t-Test

	Difference between Changes	Standard Error of Difference	t	P
Total Cholesterol	3.4	4.18	0.84	..
Total Phospholipids	5.0	5.15	0.96	..

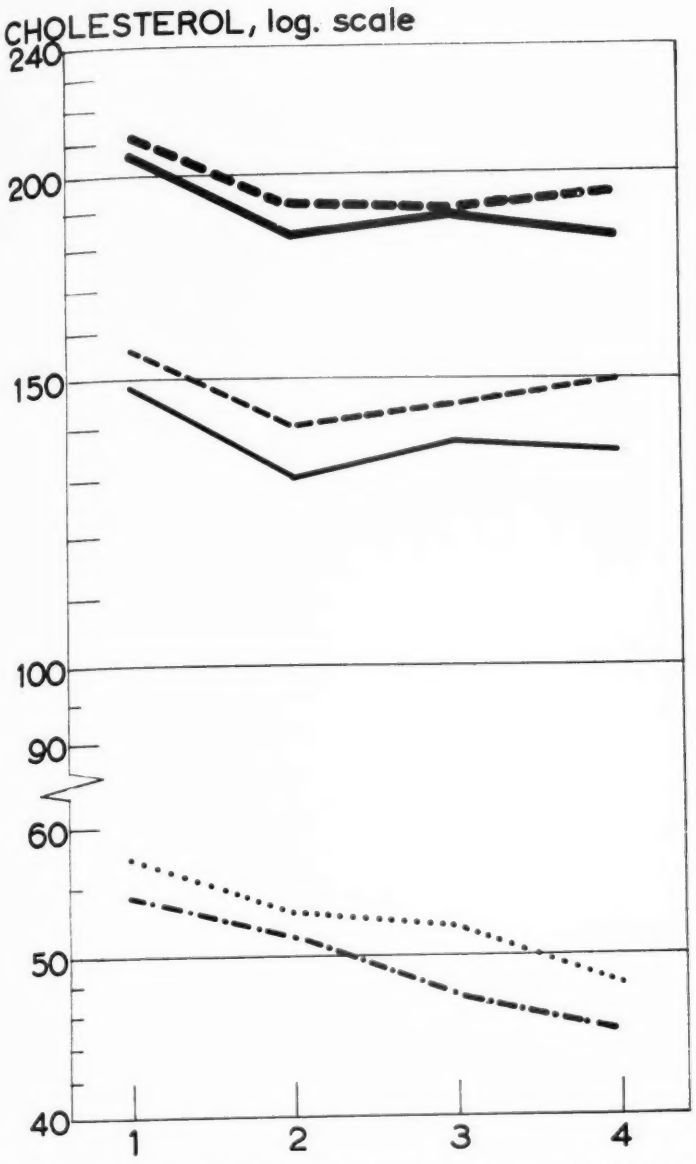


Fig. 5. Mean changes in total cholesterol and in α- and β-cholesterol in service class groups of 94 A-men and 93 B-men at different determinations during military service.

Total cholesterol : A-men , B-men
β-cholesterol : —»— , —»—
α-cholesterol : —»— , —»—

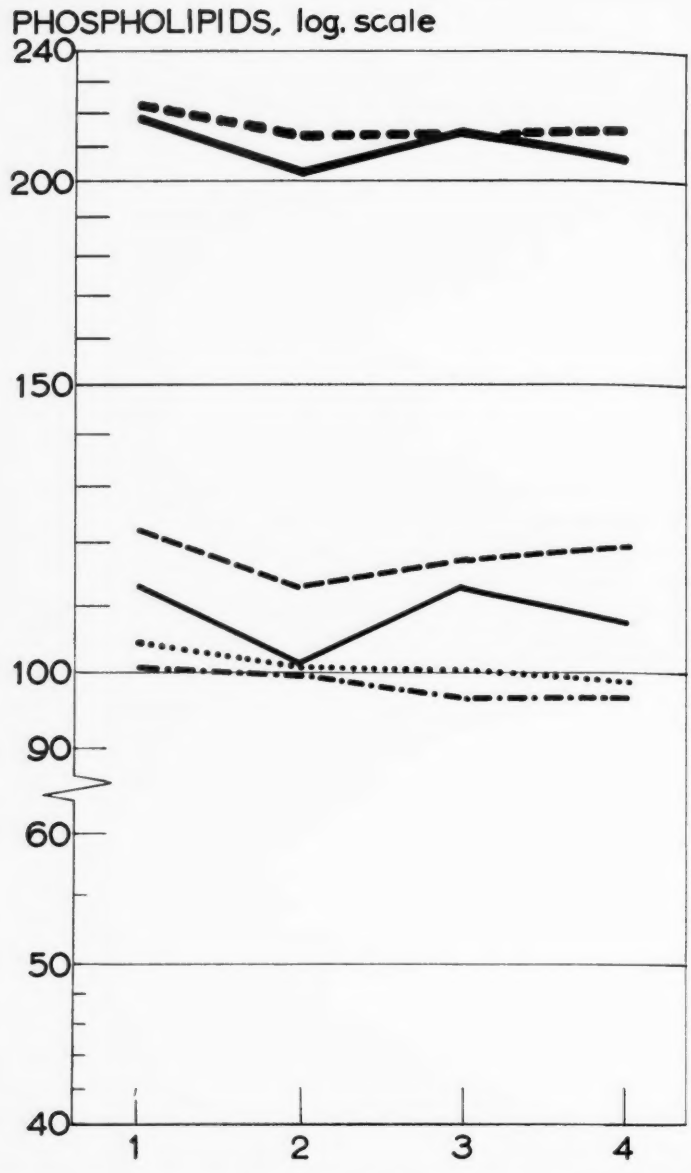


Fig. 6. Mean changes in total phospholipids and in α- and β-phospholipids in service class groups of 94 A-men and 93 B-men at different determinations during military service.

Total phospholipids : A-men , B-men
β-phospholipids : —»— , —»—
α-phospholipids : —»— , —»—

SERUM LIPIDS IN THE OCCUPATIONAL GROUPS

As was already stated in the Review of the Literature, page 21, several investigators have found a higher serum total cholesterol level in sedentary workers than in persons engaged in heavy physical labor. By civilian occupation, 81 of the men in the present study were sedentary workers and 106 laborers. The curves for the mean values of serum lipids in these two groups at each determination are shown in figs. 7 and 8, and the mean values and standard errors of the mean are given in table 20 in the Appendix.

As appears in table 8a, there was no difference between the sedentary worker and laborer groups at the beginning of the military service with respect to any of the examined lipids. The decrease in the total cholesterol and total phospholipids during the basic training period also showed no difference between the occupational groups (table 8b). Likewise, the decreases in cholesterol and phospholipids in the α- and β-lipoprotein fractions were parallel in these groups, as is seen in figs. 7 and 8.

TABLE 8

a. Testing of Differences in Serum Lipids between Occupational Groups of 81 Sedentary Workers and 106 Laborers at the Beginning of Military Service: t-Test

	Difference between Groups	Standard Error of Difference	t	P
Total Cholesterol	4.8	5.09	0.94	..
α-Cholesterol	1.9	1.73	1.10	..
β-Cholesterol	3.0	5.68	0.53	..
Total Phospholipids	2.5	5.00	0.50	..
α-Phospholipids	3.8	2.92	1.30	..
β-Phospholipids	1.2	3.95	0.30	..

b. Testing of Differences in Changes in Total Cholesterol and Total Phospholipids between Occupational Groups of 81 Sedentary Workers and 106 Laborers during the Basic Training Period: t-Test

	Difference between Changes	Standard Error of Difference	t	P
Total Cholesterol	3.0	4.15	0.73	..
Total Phospholipids	0.8	5.63	0.15	..

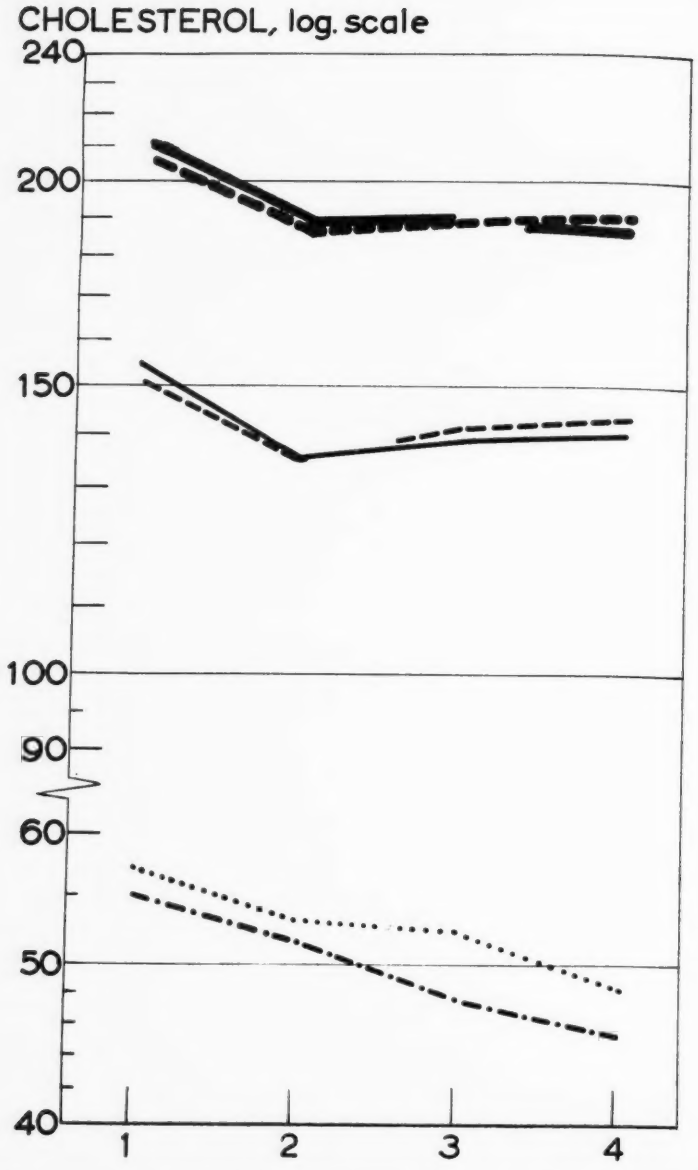


Fig. 7. Mean changes in total cholesterol and in α- and β-cholesterol in occupational groups of 81 sedentary workers and 106 laborers at different determinations during military service.

Total cholesterol : ——— sedentary workers , - - - - laborers
β-cholesterol : ——— —»— , - - - - —»—
α-cholesterol : ····· —»— , -·-·-· —»—

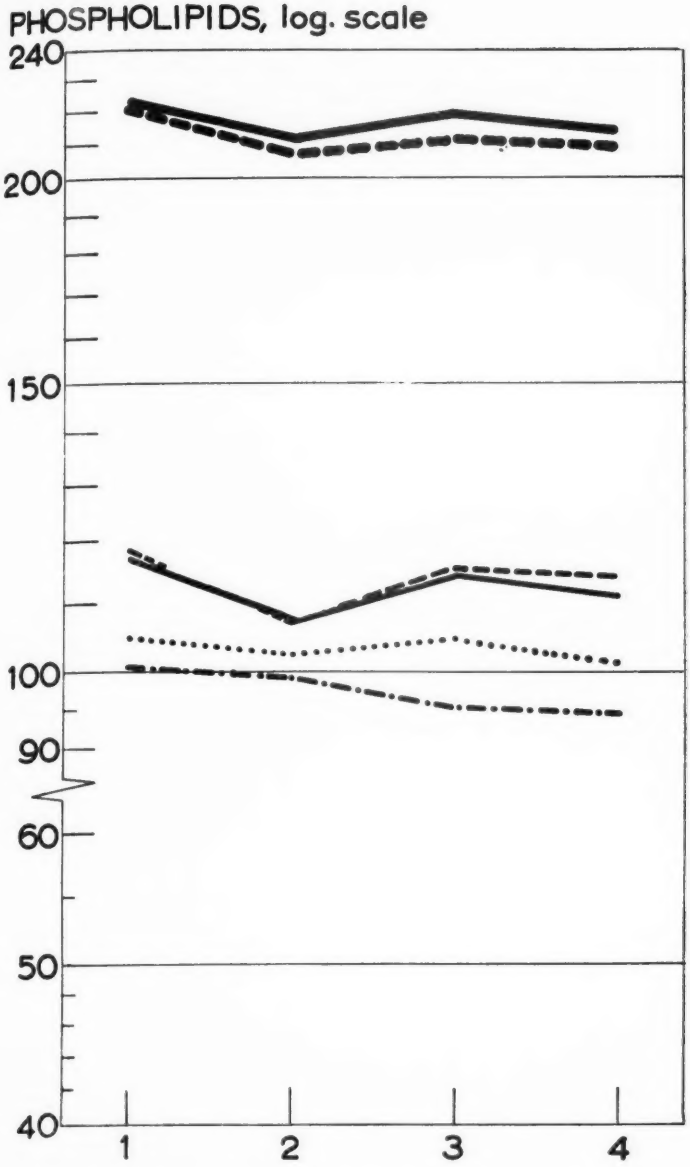


Fig. 8. Mean changes in total phospholipids and in α- and β-phospholipids in occupational groups of 81 sedentary workers and 106 laborers at different determinations during military service.

Total phospholipids : ——— sedentary workers , - - - - laborers
β-phospholipids : ——— —»— , - - - - —»—
α-phospholipids : ····· —»— , -·-·-· —»—

SERUM LIPIDS IN THE OCCUPATIONAL SUBGROUPS IN THE SERVICE CLASSES

Of the A-men, who were undergoing infantry training, 51 were sedentary workers and 43 were laborers by civilian occupation. The B-group, which was being trained in light fatigue duty, consisted of 30 sedentary workers and 63 laborers. The mean values and standard errors of the mean for the serum lipids in each of these occupational subgroups are shown in table 21 in the Appendix.

The change in physical activity from the civilian occupation to the basic military training was greatest in the A-sedentary worker and B-laborer subgroups, but in a converse direction. The A-sedentary workers, who had been accustomed to but little muscular work in civilian life, had after entry into military service a physically strenuous training. The B-laborers, again, who as civilians had been accustomed to heavy physical labor, now had only light physical activity in fatigue duty. The curves for the mean values of serum lipids in these two subgroups are shown in figs. 9 and 10.

In comparing the changes in serum lipids in the A-sedentary worker and B-laborer subgroups, it can be seen that the decrease in the total cholesterol and phospholipids was not greater in the A-sedentary worker subgroup than in the B-laborer subgroup (table 9). The changes in these lipids in the lipoprotein fractions also seem to be parallel in the two subgroups of men, as seen from figs. 9 and 10.

TABLE 9

Testing of Differences in Changes in Total Cholesterol and Total Phospholipids between Subgroups of 51 A-sedentary Workers and 63 B-laborers during the Basic Training Period: t-Test

	Difference between Changes	Standard Error of Difference	t	P
Total Cholesterol	5.3	5.43	0.97	..
Total Phospholipids	3.9	6.87	0.56	..

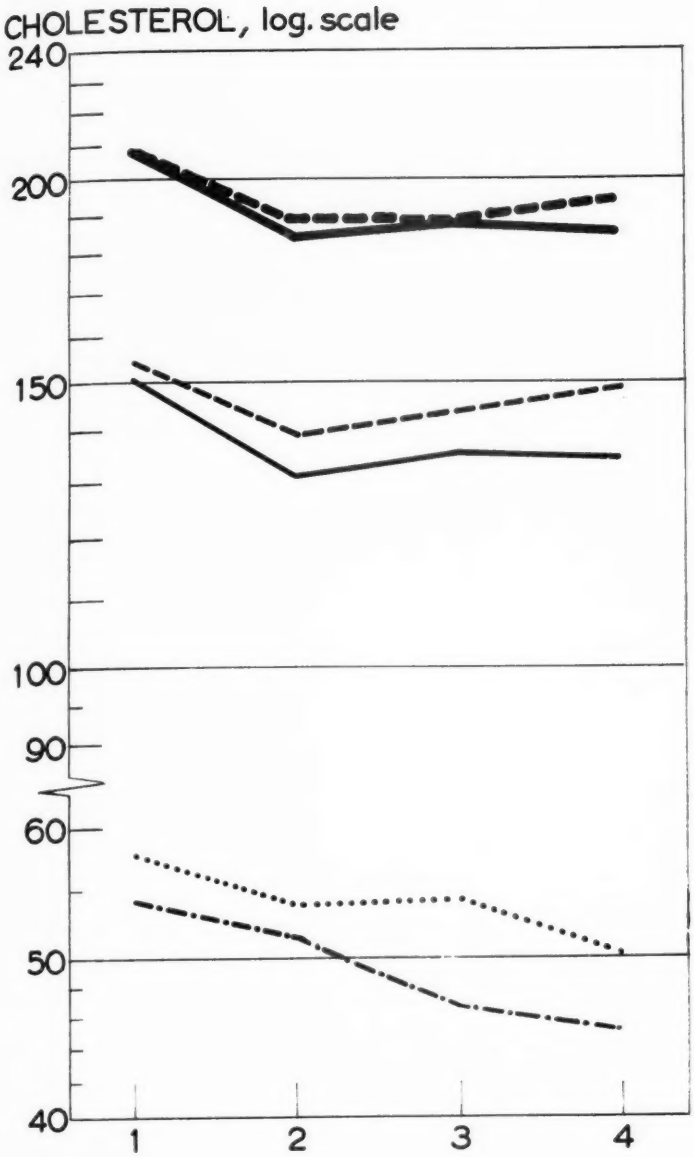


Fig. 9. Mean changes in total cholesterol and in α- and β-cholesterol in subgroups of 51 A-sedentary workers and 63 B-laborers at different determinations during military service.

Total cholesterol : A-sedentary workers , B-laborers
β-cholesterol : — » — , — » —
α-cholesterol : — » — , — » —

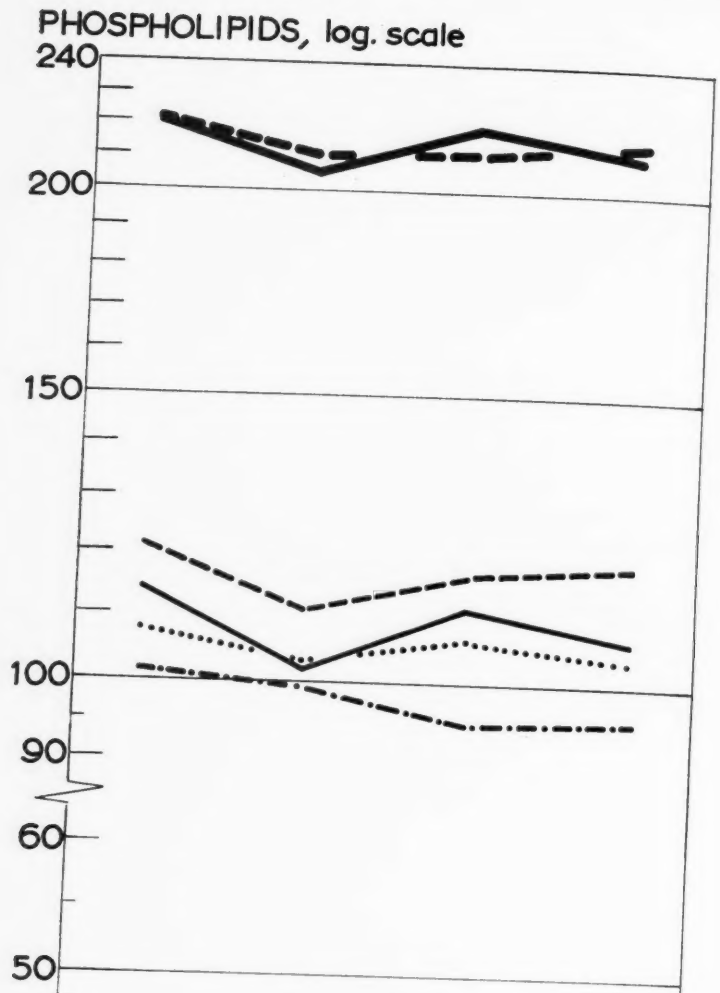


Fig. 10. Mean changes in total phospholipids and in α- and β-phospholipids in subgroups of 51 A-sedentary workers and 63 B-laborers at different determinations during military service.

Total phospholipids : ——— A-sedentary workers , - - - - B-laborers
β-phospholipids : ——— —»— , - - - - —»—
α-phospholipids : ..... —»— , -·-·- —»—

SERUM LIPIDS IN THE DIFFERENT CONTINGENTS

Keys *et al.* (1958b) observed that the serum total cholesterol level of the Finnish male population was higher in winter than in summer. In the present investigation the different contingents entered military service at intervals of four months. The first contingent (66 men) began its service in February, the second contingent (66 men) in June, and the third contingent (55 men) in October. Fig. 11 shows the curves for the mean values of serum lipids in each contingent at the different determinations. In table 22 in the Appendix are listed the mean values and standard errors of the mean for the analysed lipids at each determination in the three contingents.

It is seen from table 10 that at the first determination there was no difference in serum total cholesterol and total phospholipid levels of men who entered military service at different seasons. The amounts of these lipids in the α- and β-lipoprotein fractions appeared to be similar in the different contingents, as is seen from table 22 in the Appendix.

TABLE 10

Testing of Differences in Total Cholesterol and Total Phospholipids between the Three Contingents at the Beginning of Military Service: Variance Analysis

	Sum of Squares	Degrees of Freedom	Mean Square	v^2	P
Total Cholesterol					
Between Contingents	36	2	18.0	0.01	..
Within Contingents	259 154	184	1 408.4		
Total	259 190	186			
Total Phospholipids					
Between Contingents	3 461	2	1 730.5	1.52	..
Within Contingents	209 357	184	1 137.8		
Total	212 818	186			

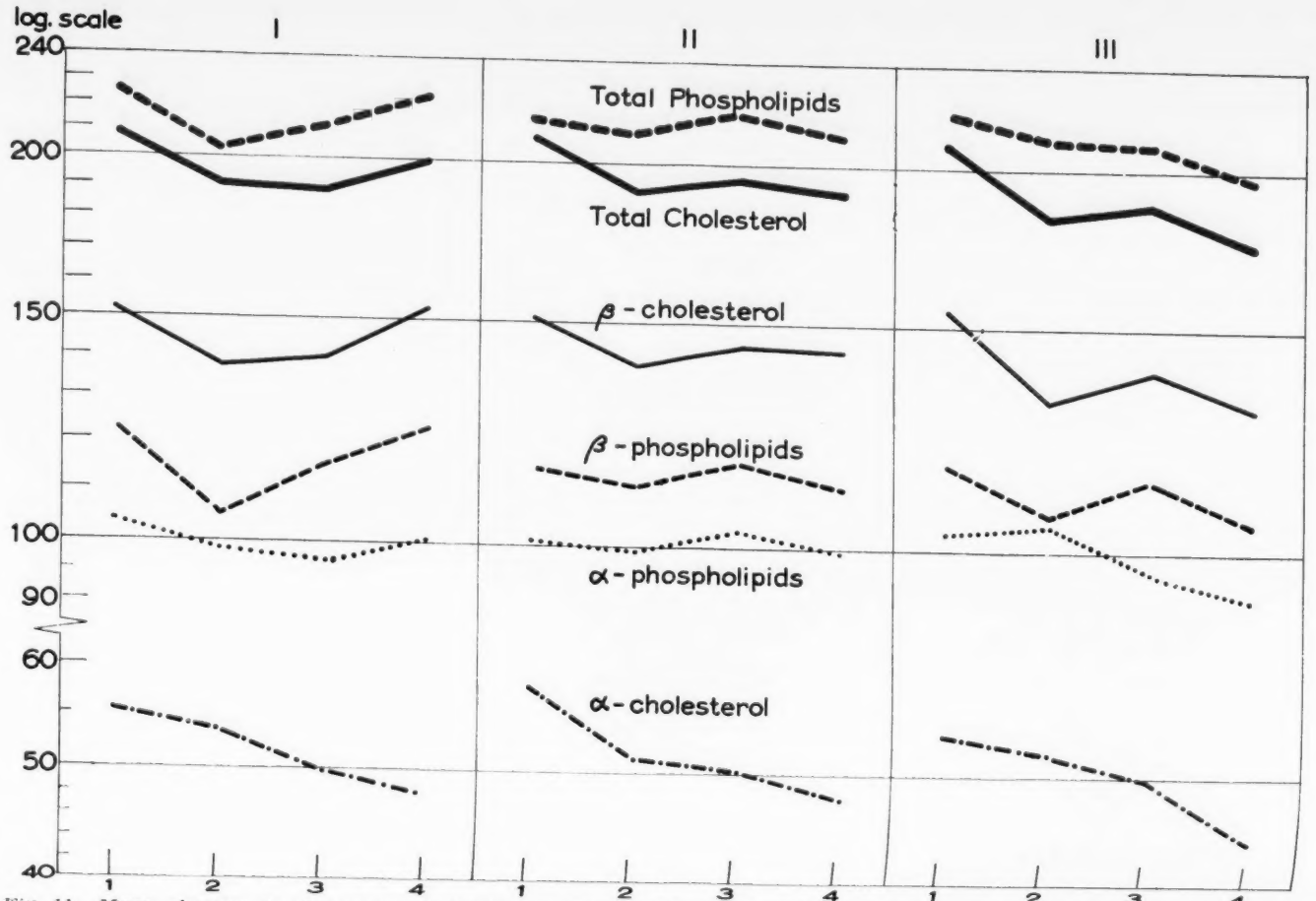


Fig. 11. Mean changes in the serum lipids in the three continents at different determinations during military service.

The mean changes in the total cholesterol and phospholipids in the three contingents are listed in table 11. The changes occurring in total cholesterol between the first and second determinations and between the second and third determinations were similar in the three contingents (table 12a). There was a probable difference ($P < 0.05$) in the decrease in total phospholipids between the first and second determinations in the different contingents (table 12b). On the other hand, the changes in total cholesterol and total phospholipids between the third and fourth determinations showed a highly significant difference ($P < 0.001$) in the three contingents. The changes in the β-cholesterol and β-phospholipids also seem to follow the changes in the corresponding total amounts (fig. 11).

TABLE 11

Changes in Total Cholesterol and Total Phospholipids between Different Determinations in the Three Contingents

	Between Determinations	Contingent I	Contingent II	Contingent III	Total Series
Total Cholesterol Change	1—2	—18.2	—19.2	—25.5	—20.7
	2—3	— 1.6	+ 4.2	+ 5.3	+ 2.5
	3—4	+11.0	— 3.8	—13.8	— 1.6
Total Phospholipid Change	1—2	—22.7	— 6.4	— 9.1	—12.9
	2—3	+ 7.9	+ 9.2	— 1.2	+ 5.7
	3—4	+11.2	— 9.1	—13.5	— 3.3

TABLE 12

a. Testing of Differences in Changes in Total Cholesterol between Different Determinations in the Three Contingents: Variance Analysis

Differences between Determinations 1—2	Sum of Squares	Degrees of Freedom	Mean Square	v^2	P
Between Contingents	1 806	2	903.0	1.11	..
Within Contingents	149 612	184	813.1		
Total	151 418	186			
Differences between Determinations 2—3					
Between Contingents	1 427	2	713.5	1.14	..
Within Contingents	115 038	184	625.2		
Total	116 465	186			
Differences between Determinations 3—4					
Between Contingents	18 841	2	9 420.5	14.7	0.001
Within Contingents	118 248	184	642.7		
Total	137 089	186			

b. Testing of Differences in Changes in Total Phospholipids between Different Determinations in the Three Contingents: Variance Analysis

Differences between Determinations 1—2	Sum of Squares	Degrees of Freedom	Mean Square	v^2	P
Between Contingents	9 969	2	4 984.5	4.16	0.05
Within Contingents	220 229	184	1 196.9		
Total	230 198	186			
Differences between Determinations 2—3					
Between Contingents	3 779	2	1 889.5	2.66	..
Within Contingents	130 645	184	710.0		
Total	134 424	186			
Differences between Determinations 3—4					
Between Contingents	21 701	2	10 850.5	16.4	0.001
Within Contingents	121 884	184	662.4		
Total	143 585	186			

CHANGES IN BODY WEIGHT AND SERUM TOTAL CHOLESTEROL

The mean body weights in the different groups at the different determinations are listed in table 23 in the Appendix. The mean weight of all the men remained nearly unchanged during the basic training period, after which it increased evenly at each determination. The increase in the mean weight in the total series during the whole investigation period was 2.7 kg.

On examining the different groups it is observed that the changes in body weight during the whole investigation period were similar in groups of A- and B-men (fig. 12). On the other hand, the group of men who were sedentary workers by civilian occupation lost weight during the basic training period, after which it showed a weight gain which was parallel with the gain in the laborer group, whereas the laborer group showed a linear increase in weight at each determination (fig. 13). The weight increase during the entire investigation period averaged 1.7 kg in the sedentary worker group and 3.4 kg in the laborer group. The difference in the change in body weight during the basic training period in the sedentary worker and laborer groups was highly significant ($P < 0.001$), as is seen in table 13. Although the changes in body weight in these two groups were different, no difference was found in the serum total cholesterol, as was already shown in table 8b.

It may be suggested that the weight reduction of the sedentary workers during the basic training period was due to the better state of nutrition of the men in this group on entering military service than that of the men in the laborer group. The relative body weights of the men were therefore calculated by means of the tables of Metropolitan Life Insurance Company.

TABLE 13

Testing of Difference in Changes in Body Weight between Occupational Groups of 81 Sedentary Workers and 106 Laborers during the Basic Training Period: t-Test

	Change in Body Weight	Difference between Changes	Standard Error of Difference	t	P
Sedentary Workers	— 0.58				
		1.52	0.34	4.40	0.001
Laborers	+ 0.94				

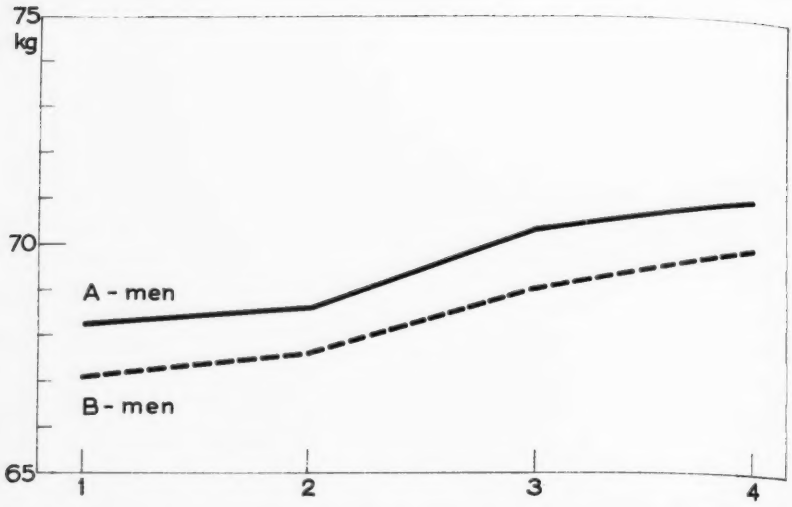


Fig. 12. Mean changes in body weight in service class groups of 94 A-men and 93 B-men at different determinations during military service.

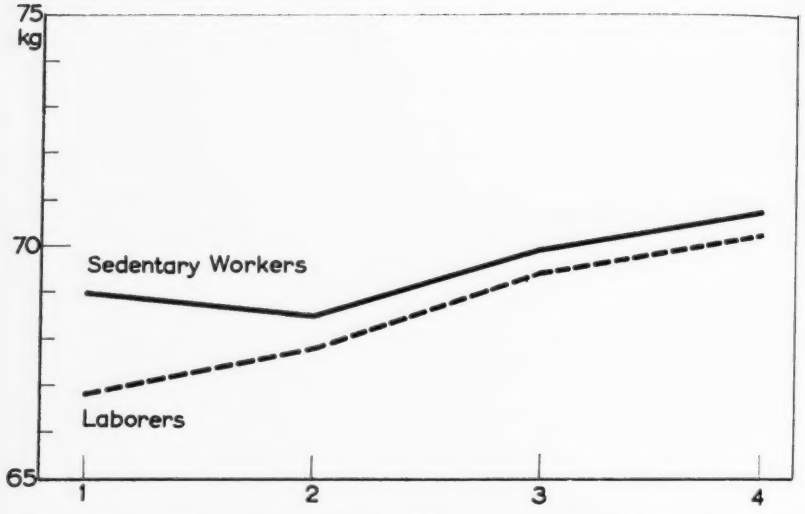


Fig. 13. Mean changes in body weight in occupational groups of 81 sedentary workers and 106 laborers.

The mean relative body weight of all the men on entering military service was 1.04. The relative body weights at this time were very similar in the groups in which the weight changes during the basic training period differed most from each other. The mean relative body weight of the sedentary worker group was 1.04 and that of the laborer group 1.05. A distribution of the men into groups according to their relative body weights on entering military service failed to reveal any correlation between the serum total cholesterol and the relative body weight. A number of investigators have found that the serum lipids are correlated to the state of nutrition or body build (Gertler *et al.* 1950a, Tanner 1951, Gofman and Jones 1952, Walker 1953), while some others have observed only a tendency to correlation (Keys 1949, Kornerup 1950) and Lindholm (1956) has found no correlation. It is to be observed, however, that the relative body weights of the men in the present investigation differed very little from each other, because obese and very thin subjects were excluded from the material.

Examination of the individual changes in the body weights of the men during the basic training period, when the differences were greatest, shows that 24 men gained during this period 3 kg or more (mean 4.6 kg) and 14 men lost 3 kg or more (average 4.3 kg). The serum total cholesterol of the men who gained weight declined during the basic training period from 203.5 mg per cent to 180.3 mg per cent, and that of the men who lost weight dropped from 222.3 mg per cent to 194.4 mg per cent. As is seen in table 14, there was no difference in the changes in the total cholesterol in these two groups.

TABLE 14

Dependence of Change in Total Cholesterol from Change in Body Weight during the Basic Training Period (Men with Greatest Changes in Body Weight) : t-Test

	Number of Men	Change in Cholesterol	Difference between Changes	Standard Error of Change	t	P
Weight Gain $\geq$ 3 kg	24	— 23.2				
			4.7	9.23	0.50	..
Weight Loss $\geq$ 3 kg	14	— 27.9				

POSSIBLE RELATIONSHIP OF OTHER FACTORS AND SERUM TOTAL CHOLESTEROL

The serum cholesterol level has been found by some investigators to be higher in smokers than in non-smokers (Gofman *et al.* 1955, Karvonen *et al.* 1959). A correlation between the serum cholesterol level and smoking was also observed by Thomas (1958), while Thomas and Eisenberg (1959) noted that the stopping of smoking did not influence the serum cholesterol. In the present investigation 169 of the examined men were questioned concerning their smoking habits. It was found that 73 (43.2 per cent) definitely were non-smokers. The smokers' group, totaling 60 men, consisted of those who had smoked for at least one year before entering military service and who smoked at least ten cigarettes per day. Nearly all of these men smoked American type cigarettes. Pipe smokers, a few in number, were not included in these groups. The mean serum total cholesterol values in groups with different smoking habits are shown in table 15. There appeared to be no difference in the serum total cholesterol levels at the beginning of military service in the groups distributed according to tobacco smoking habits.

TABLE 15

Mean Values and Standard Errors of the Mean for Total Cholesterol in Different Smoking Habit Groups at the Beginning of Military Service

	Number of Men	Mean Cholesterol and Standard Error of Mean
Non-smokers	73	205.6 ± 3.48
10—19 Cigarettes/Day	35	209.4 ± 5.78
20 or More Cigarrettes/Day	25	203.3 ± 6.65

When the men were distributed into urban and rural groups according to their place of residence, there were 131 men from rural districts and 56 from cities, the latter including 3 men from market towns. Nearly 80 per cent of the urban residents were from Helsinki. The rural inhabitants were chiefly from the vicinity of Helsinki and from south-western Finland; however, a large number of the B-men came from various parts of

Finland. The men in the three contingents came approximately from the same regions. The mean serum total cholesterol of the urban residents (209.5 ± 5.68 mg per cent) was very similar to that of the rural residents (208.4 ± 3.06 mg per cent).

In the selection of the subjects for this investigation an effort was made to form as similar age groups as possible. It will be observed from table 23 in the Appendix that the mean ages in the different groups were very similar. The youngest subject was 18 years and the oldest 26 years of age on entering military service. The mean age of the total series at the beginning of the service was 19.9 years; 181 men were aged 18—23 years and 6 men 24—26 years.

The mean hemoglobin level of the blood was very similar in the different groups, and no changes took place during the military service.

SERUM TOTAL CHOLESTEROL AFTER DISCHARGE FROM MILITARY SERVICE

After the men were discharged from military service, blood samples were taken from 18 men in February 1959, when they had lived under civilian conditions for about six months or more. The blood sample was drawn under similar conditions as earlier in this investigation. The serum total cholesterol, sedimentation rate and blood hemoglobin were also determined by the same methods as earlier.

Persons residing in Helsinki only were available for the follow-up examination. They included 14 men who had belonged to the A-sedentary worker subgroup and 4 who had been in the B-sedentary worker subgroup. Four men had been in contingent I, six in II, and eight in III. Since their discharge from military service the men in contingent I had lived under civilian conditions for over one year and those in contingent III for about six months. They had been in good health during this time. In two cases the sedimentation rate was 15 mm/1 hr. at the time of follow-up examination, but since the men were subjectively healthy they were not excluded from this follow-up examination.

Table 16a shows the mean values and standard errors of the mean for the serum total cholesterol in this group of 18 men during military service and after discharge. As is seen in table 16b there had been a significant decrease in the serum total cholesterol level of this group during the basic training period. Under civilian conditions the serum total cholesterol had reverted to the level seen at the beginning of the military service.

TABLE 16

a. Mean Values and Standard Errors of the Mean for Total Cholesterol in 18 Men during Military Service and under Civilian Conditions after Discharge from Service

During Military Service Determination				After Discharge from Service
1	2	3	4	
219.9 ± 11.12	196.8 ± 9.53	208.6 ± 9.79	189.3 ± 9.04	221.3 ± 10.46

b. Testing of Changes in Total Cholesterol between Determinations 1 and 2 during Military Service, and between Determination 2 and Determination after Discharge from Service of 18 Men : t-Test

	Change	Standard Error of Change	t	P
Between Determinations 1—2	— 23.1	6.17	3.74	0.01
Between Determ. 2 and Determ. after Discharge	+ 24.5	6.21	3.95	0.01

VACCINATION AND SERUM TOTAL CHOLESTEROL DURING THE BASIC TRAINING PERIOD

During the basic training period in the Finnish army, the men are vaccinated against smallpox, tetanus, diphtheria and *Salmonella typhi* and *paratyphi*. It is a well known fact that local lymphangitis and lymphadenitis may occasionally develop in association with smallpox vaccination, and that vaccination against *Salmonella* may be accompanied by subfebrile temperature. Several investigators have observed a low serum cholesterol level in various infectious diseases (Chauffard *et al.* 1911b, Denis 1917, Kipp 1920, Stoesser and McQuarrie 1935, Stoesser 1938, Steiner and Turner 1940). It was reported by Chauffard

et al. (1911a) that the cholesterol level declined in patients with typhoid fever at an early stage of the disease and increased above the normal level during convalescence. They suggested that this increase is a sign of the development of immunity by the disease. However, the present writer has found only a single mention of vaccination influencing the serum lipids. Groen *et al.* (1952) presumed that the decreased serum cholesterol in one person may have been caused by vaccination.

Since, in consideration of the above mentioned reports, the decrease in the serum lipids during the basic training period might possibly be attributed to the vaccinations given during this period, a supplementary experiment was carried out to clarify this point. From the same battalion in which the A-men had served, 74 men who by civilian occupation were laborers were selected according to the criteria used in the main investigation. These men entered military service in February 1959. Of them 37 were given the routine army vaccinations, while 37 were not vaccinated. Since the present investigation had shown that all the lipids examined followed mainly the changes in total cholesterol, only the latter was determined. All the blood samples were drawn under conditions similar to those in the main investigation. The sedimentation rate and body weight were determined at the time of sampling, and the blood hemoglobin and height when the men entered military service. All men who did not fill the earlier criteria for health were excluded. Only those men, totaling 66 (33 vaccinated and 33 non-vaccinated) who were present in a healthy condition at each blood sampling were approved for this supplementary study.

As in the main investigation, the first blood sample was taken when the men arrived for military service. Since the purpose was to find out whether the decrease in the serum cholesterol level occurs already at the beginning of the basic training period, the second sample was taken already after two weeks and the third after four weeks of service. The fourth sample was drawn after eight weeks of service, coinciding with the time of the second blood sample in the main investigation.

The mean values and the standard errors of the mean for the serum total cholesterol in the vaccinated and non-vaccinated groups are presented in table 17a. It is seen in table 17b that a highly significant drop ($P < 0.001$) occurred in the serum cholesterol during the first two weeks of service. The decrease was no greater in the vaccinated than in the non-vaccinated group (table 17c).

On examining the individual changes occurring during the first two weeks it was observed that the serum total cholesterol had increased in 1 case only (10 mg per cent), was unchanged in 9 cases ($\leqq \pm 9$ mg per cent), and had declined in 56 cases. The largest decrease was 138 mg per cent.

TABLE 17

a. Mean Values and Standard Errors of the Mean for Total Cholesterol in Vaccinated and Non-Vaccinated Groups in Supplementary Study

	Number of Men	Determination 1	2	3	4
Vaccinated	33	197.8 ± 5.76	159.6 ± 4.13	168.6 ± 4.73	173.0 ± 6.17
Non-Vaccinated	33	192.1 ± 4.41	163.3 ± 4.26	171.2 ± 5.17	174.1 ± 3.89
Total	66	194.9 ± 3.62	161.6 ± 2.96	169.9 ± 3.48	173.6 ± 3.62

b. Testing of Changes in Total Cholesterol between Determinations 1 and 2 and Determinations 2 and 4 in Total Series of 66 Men in Supplementary Study : t-Test

	Change	Standard Error of Change	t	P
Between Determinations 1—2	— 33.4	2.80	11.93	0.001
Between Determinations 2—4	+ 12.0	2.64	6.03	0.001

c. Testing of Difference in Changes in Total Cholesterol between Determinations 1 and 2 in Vaccinated and Non-Vaccinated Groups in Supplementary Study

	Change	Difference between Changes	Standard Error of Difference	t	P
Vaccinated	— 38.2	9.7	5.51	1.76	..
Non-Vaccinated	— 28.8				

At the following determinations the serum cholesterol increased and at the end of the basic training period it was highly significantly ($P < 0.001$, table 17b) higher than after the first two weeks of service.

The increase in the body weight of the men averaged 1.4 kg during the first two weeks of the supplementary study and 1.6 kg during the whole basic training period. The changes in weight were similar in the vaccinated and the non-vaccinated groups.

DISCUSSION

The mean serum total cholesterol level observed in this investigation at the beginning of military service (208.8 mg per cent) corresponds to that found by Keys *et al.* (1958b) in Finnish men 20—29 years of age under civilian conditions. A similar total cholesterol level was reported in young North American male subjects by Mann *et al.* (1955a), Scrimshaw *et al.* (1957b) and Armstrong *et al.* (1957), who used the same method of cholesterol determination as in the present work. In the grouping of the men by civilian occupations, the mean total cholesterol values for sedentary workers (211.5 mg per cent) and laborers (206.7 mg per cent) at the beginning of military service also are in accordance with the occupational physical activity group means (199—226 mg per cent) obtained by Keys *et al.* (1958b) in serum cholesterol studies in the Finnish male population aged 20—29 years.

The relative distribution of cholesterol in the lipoprotein fractions at the beginning of military service (on the average, 72.4 per cent of the cholesterol was present in the β-fraction) was similar to the finding of Miettinen (1956) in healthy Finnish men 20—39 years of age (73.8 per cent in the β-fraction) by the same method of electrophoresis and cutting technique of paper strips. On the other hand, both the relative and the absolute amounts (mean 152.7 mg per cent) of β-cholesterol at the beginning of military training were lower than that reported by Keys *et al.* (1958b) in Finnish males aged 20—29 years. The absolute amount of α-cholesterol at the beginning of military service (mean 56.0 mg per cent) was higher than the levels observed by Keys *et al.* (1958b) in Finnish men aged 20—29 engaged in different occupations (group means 41.6—46.2 mg per cent) and in the male populations in a number of other countries (Farquhar and Sokolow 1958, Keys *et al.* 1958c).

The mean value of 221.1 mg per cent obtained for the total phospholipids at the beginning of military service was higher than the mean of 245 mg per cent seen by Miettinen (1956) in healthy Finnish males aged 20—39 years. This difference may be due to the higher age of the men studied by Miettinen, for the serum total phospholipid level has been found to rise steeply after the twentieth year (Adlersberg *et al.* 1956, Schaefer *et al.* 1958). These investigators reported in young American men a total phospholipid level similar to that seen at the beginning of military training in the present investigation, and the lipid phosphorus level found by Schlessinger (1958) in American army draftees is in accord with the phospholipid level at the beginning of military service in the present investigation. Of total phospholipids, an average of 52.9 per cent was present in the β-lipoprotein fraction at the beginning of military service. Using the same electrophoresis technique as was employed in the present work, it was found by Nikkilä (1952) that nearly one-half and by Miettinen (1956) that slightly over one-half of the phospholipids migrate with this fraction in young healthy males.

During the basic training period (first eight weeks) the mean serum total cholesterol level underwent a highly significant decrease from 208.8 mg per cent to 188.1 mg per cent. At the later determinations, the last of which was made 32 weeks later, the total cholesterol was still at the reduced level to which it had dropped. The decrease in total phospholipids from 221.1 mg per cent to 208.2 mg per cent during the basic training period was also highly significant. After the basic training period the serum total phospholipids showed a significant rise toward the initial level, which, however, was not regained during the experimental period. In numerous dietary experiments there has been observed a parallel drop in the total cholesterol and total phospholipids (Kempner 1949, Ahrens *et al.* 1957, Kinsell *et al.* 1953a, 1953b, 1954), while in some studies the total phospholipids decreased less than the total cholesterol (Ahrens *et al.* 1954, Shapiro *et al.* 1957, Farquhar and Sokolow 1958).

The changes in the β-cholesterol and β-phospholipids during the period of the present investigation appear to conform with the changes in the corresponding total amounts. In studies carried out in various countries it has been found that differ-

ences in the total cholesterol levels are usually paralleled by differences in the cholesterol contained in the β-lipoprotein fraction (Bronte-Stewart *et al.* 1955, Keys *et al.* 1958b, 1958c, Brunner and Lobl 1958). Dietary experiments have also shown that changes in total cholesterol take place on the base of changes in β-cholesterol (Bronte-Stewart *et al.* 1956, Keys and Anderson 1957, Keys *et al.* 1957a, Anderson *et al.* 1957a, Farquhar and Sokolow 1958).

The α-cholesterol, on the other hand, has been found to remain unchanged in dietary experiments in which changes occurred in the β-cholesterol (Anderson *et al.* 1957a, Farquhar and Sokolow 1958). In investigations which have been performed in a number of countries and in which differences in the total cholesterol level were found to be based on differences in the β-cholesterol, the α-cholesterol was not different (Keys *et al.* 1958 b, 1958 c). However, in contrast to the results of other investigations, it was found by Bloomberg *et al.* (1958) that young urban South African Bantu males have a higher α-cholesterol level than young rural Bantu males. In men of various age groups whose serum total cholesterol had increased with age because of an increased β-cholesterol level there was no change in the α-cholesterol (Nikkilä 1953, 1955, Keys *et al.* 1958b). The highly significant drop in the α-cholesterol observed in the present investigation between the first and last determinations during military service (from 56.0 mg per cent to 46.7 mg per cent) indicates — contrary to all earlier observations but one — that a change may take place also in these lipids in healthy men. Keys *et al.* (1955a) found indeed that also α-cholesterol fell during a low-fat diet. A highly significant decrease was also seen in the α-phospholipids during military service (from 103.1 mg per cent to 97.5 mg per cent). This change, as also the change in the α-cholesterol, was linear at every determination during the period of investigation.

In the supplementary study the serum total cholesterol of 66 men was found to undergo a highly significant decrease (from 194.9 mg per cent to 161.6 mg per cent) already during the first two weeks of service. An increase occurred thereafter, and at the end of the basic training period the cholesterol had reached the level of 173.6 mg per cent. This increase is highly significant.

The decrease in the total cholesterol during the entire basic training period of eight weeks, as shown by the supplementary study (from 194.9 mg per cent to 173.6 mg per cent), appeared to be similar to that seen during the corresponding period in the main investigation (from 208.8 mg per cent to 188.1 mg per cent). It therefore seems probable that also in the main investigation the total cholesterol had been lower than the level observed at the end of the basic training period.

The reason for the decrease in the serum lipids observed during military service in the present investigation could be thought to be the difference in the diet under army and civilian conditions. It was not possible to obtain detailed information on the diet of the men in civilian life, but it may be presumed to have corresponded to that observed by Roine *et al.* (1958) in Finland. According to their investigation, fat accounted for 35 per cent of the total calories. The army food in the present investigation was found to contain about 30 per cent fat of the total calories. The percentage of fat was very similar in the two battalions to which the men in the present investigation belonged, and there were no consistent variations between summer and winter in dietary constituents (table 1). On the basis of these two investigations the fat calorie percentage was about 5 per cent lower in the army than in the civilian diet. This difference in the fat calories can hardly provide an explanation for the decrease in the serum lipids during the basic training period, especially since the decrease of 33.4 mg per cent in the serum cholesterol from the initial level of 194.9 per cent, as seen in the supplementary study, was of a magnitude that has been seen only in connection with a very radical reduction of dietary fat (Kempner 1948, 1949, Starke 1950, Hatch *et al.* 1955). In addition, the manner of serving the meals and the table habits give the men very little opportunity to reduce the percentage of fat by the selection of foods.

Schlessinger (1958) found that the serum total cholesterol and S_f^o 20—400 lipoproteins increased in American army draftees during the basic training period. In his opinion this was due to the richer fat content of army food as compared with civilian food and to the increase of body weight of the men on this diet. According to information received by Schlessinger, fat

comprised about 50 per cent of the total calories. However, there was at the same time a decrease in the S_f^o 0—12 and S_f^o 12—20 lipoproteins and a transitory decrease in the lipid phosphorus.

In a comparison of the various dietary fats, their degree of saturation must also be taken into consideration, since it may influence the serum lipids, as was mentioned above in the Review of the Literature. A very large proportion of the dietary fat used in Finland is highly saturated animal fat, and most of the vegetable fats — consumed chiefly as margarine — are also highly saturated. The ratio of saturated fatty acids to poly-ethenoids in civilian diet was 6.6—7.5 (Roine *et al.* 1958). The dietary study made in the present investigation showed that the ratio of saturated fatty acids to poly-ethenoids in the diet of the two regiments was very similar to that observed by Roine *et al.* and varied between 6.6 and 7.2. It seems very natural, indeed, that the army food is in this respect similar to civilian food, since the purchases of army provisions are usually made in the free civilian market.

In consideration of the facts mentioned above it would appear probable that the difference in the diet during military service as compared with the civilian diet was so small that it can hardly serve as explanation for the decrease in the serum lipid level during military service.

Changes in body weight have been found to influence the serum cholesterol (Keys *et al.* 1950a, Anderson *et al.* 1957b). The changes in body weight during military service were relatively small. During the entire investigation period (32 weeks) the men gained an average of 2.7 kg in weight. The most distinct difference in the weight changes during the basic training period was seen between the sedentary workers and laborers. The changes in body weight had an opposite trend in these two groups during the basic training period. The sedentary workers lost 0.5 kg, whereas the laborers gained 1 kg. The difference in these changes was highly significant. The decrease in the serum total cholesterol level in these groups during this period did not differ, however. The above mentioned changes in weight occurred during eight weeks and therefore cannot be

compared to changes in serum lipids occurring rapidly in association with great changes in weight.

When the men who showed the greatest increases and decreases in body weight during the basic training period were formed into groups, it was observed that 24 men had lost 3 kg or more (average 4.6 kg) and 14 men had gained 3 kg or more (average 4.3 kg). Nevertheless the decline in the serum total cholesterol did not differ in these two groups. In the supplementary study a highly significant drop (from 194.9 mg per cent to 161.6 mg per cent) was seen in the total cholesterol during the first two weeks of service, although the men gained, on an average, 1.4 kg during this time. Were it assumed that the weight increase *per se* would influence the serum cholesterol, one would have expected a rise in the cholesterol level, as occurred in the weight increase experiment of Anderson *et al.* (1957b), in which the men gained an average of 2.6 kg during five weeks.

It is understandable that the amount of physical activity during military service cannot be accurately estimated on the basis of the present investigation. The dietary study, also, can give no indication of the total amount of energy expenditure by the different groups of men, as already was stated on page 31. However, on the basis of the known facts it can be concluded that the physical activity of the A-men who were undergoing a heavy physical training was considerably greater than that of the B-men receiving a light training. At the same time the other external circumstances of the A- and B-men were very similar. It was observed in the present investigation that during the basic training period, when the decrease in the serum lipids occurred, there was no difference in the decline in the serum lipids between the A- and B-men. After the basic training period, as well, when the physical activity of the A- and B-men differed still more markedly, the serum lipid level appeared to have no correlation to the physical activity.

Were it assumed that the serum lipid level would be correlated to changes in physical activity, this relationship should be most clearly evident in a comparison of the A-sedentary workers and B-laborers. The change in physical activity in com-

parison to civilian conditions was greatest in these two subgroups. The term sedentary, as applied to healthy men of this age, is not truly a factual one, even though all men who had been active in sports were excluded from the sedentary worker group. It seems natural, however, that their physical activity under civilian conditions was lower than that of the laborers, who performed heavy physical work in civilian life. The physical activity of the B-laborers was doubtlessly lower during military service than under civilian conditions. A comparison of the changes in the serum lipids of the A-sedentary workers and B-laborers during the basic training period reveals that these changes were no greater in the A-sedentary workers than in the B-laborers. The serum lipid levels after the basic training period, as well, do not appear to have a parallel trend with the physical activity in these subgroups.

It would therefore seem that physical activity under military service conditions had no effect on the serum lipids studied. Schlessinger (1958) found in draftees of the United States army an increase in the serum total cholesterol and S_f^o 20—400 lipoproteins during the physically strenuous basic training period, when the food was rich in fat. In the S_f^o 0—12 and S_f^o 12—20 lipoproteins, on the other hand, there was a decrease. In Schlessinger's opinion the diet and the physical activity together were responsible for the changes observed. Physical activity, he stated, was a factor on the basis that an increase was not seen in all the lipids mentioned, as would have been expected in view of the fat-rich diet and the increased body weight of the men. Taylor *et al.* (1957) found that the serum cholesterol was unchanged in connection with increased physical activity. The proportion of fat calories in the diet was maintained unchanged (at about 43 per cent) during the exercise period, as compared with the control periods, and the physical activity was increased sufficiently to prevent an increase in body weight. Mann *et al.* (1955c) found an unchanged serum cholesterol level during heavy physical exercise, when the percentage of fat calories in the diet was reduced from about 50 per cent to 25 per cent and when the men did not gain weight during the period of a high-calorie diet.

Although physical activity under army conditions appeared

to have no effect on the serum lipids, it is evident that the physical activity of also the B-men, representing a smaller amount of activity, deserves to be taken into consideration. It therefore is not possible to claim that, for example, the physical activity of A-men would not influence the serum lipids, in comparison to the effect of, for instance, complete inactivity. The possibility may also be considered that under dissimilar conditions (of diet, for example) the difference in the activity of the A- and B-men could have had an effect of another kind than that seen under army conditions.

In comparing the blood cholesterol level of officers in the Indian army with that of army personnel of other ranks Gopalan and Ramanathan (1957) found that officers' cholesterol level was higher, although the diet in both groups was very similar. The authors suggested the greater physical activity of the other ranks as the reason for their lower cholesterol level. Karvonen *et al.* (1958) observed that Finnish champion skiers had lower serum cholesterol level than rural population of the same age. Likewise there was noted by Keys *et al.* (1958b) in Finnish men aged 40—49 years a higher serum cholesterol level among persons occupied in light work than in those performing heavy labor. In the younger age groups, on the other hand, there was no difference in this respect. In the present investigation, no difference was seen in any of the examined lipids between the sedentary workers and the laborers at the beginning of military service. The observations in comparative investigations of this kind, however, should be accepted with reservation in respect to the physical activity, since other factors inherent in the dissimilar living conditions may also play a part.

A possible relationship between the serum cholesterol level and seasons of the year has been referred to in a number of studies. Many investigators, however, were unable to find any seasonal variations in the serum cholesterol level (McEachern and Gilmour 1932, Man and Gildea 1937, Turner and Steiner 1939, Josephson and Dahlberg 1952). On the other hand, Keys *et al.* (1958b) and Paloheimo (unpublished data) observed a higher serum cholesterol level in Finland in winter than in summer. The changes seen in the serum lipid levels under civilian conditions are not applicable as such to military service.

It is possible that many circumstances that may vary seasonally in civilian life do not do so in the army.

In the present investigation, the contingents that arrived for military service at different seasons (February, June and October) showed no difference in the serum total cholesterol and total phospholipid levels on arrival. The changes in the total cholesterol level during the first part of the military training period (i.e., changes between the first and second determinations and between the second and third determinations) also did not differ in the three contingents. The decrease in total phospholipids during the basic training period (between the first and second determinations) probably differed in the various contingents. On the other hand, at the end of military service, between the third and fourth determinations, the changes in both total cholesterol and total phospholipids in the three contingents were different to a highly significant degree. This might possibly be ascribed to seasonal variations. However, the fact that the changes during the first part of the military service were similar in the three contingents appears to be evidence speaking against the possibility of seasonal variations.

Since the decrease in the serum lipid level during military service did not appear to be explicable on the basis of dietary factors, physical activity, or changes in body weight, it seemed evident that some other factor or factors were exerting a simultaneous influence. A factor that has been found to reduce the serum cholesterol level is infection (e.g., Chauffard *et al.* 1911a, 1911b, Denis 1917, Kipp 1920, Achard *et al.* 1928, Lavergne and Kissel 1934, Stoesser and McQuarrie 1935, Stoesser 1938, Steiner and Turner 1940). On entering military service the men are given a number of vaccinations (cf. page 64). Since smallpox vaccination is frequently accompanied by local lymphangitis and lymphadenitis, and vaccination against *Salmonella* is often followed by a subfebrile temperature, it should be regarded as possible that vaccination produced an effect similar to that of infection, even if persons who were not in good health at the time of sampling were excluded on the basis of clinical features, the blood hemoglobin and the erythrocyte sedimentation rate. The supplementary study performed on 66 men to control the possible effect of vaccination revealed, however, no

greater decrease in the serum cholesterol level in vaccinated men than in non-vaccinated men.

The effect of stressor factors on the serum lipid levels has recently been emphasized in several connections. In animal experiments, various experimental arrangements have been employed to produce stress, which can be verified in animals by means of the characteristic changes produced by the stress (Selye 1956). However, Punsar *et al.* (1958) were unable to find changes in the serum cholesterol level in the rat in association with stress.

In studies made in the effort to determine the effect of stress on the serum lipid level in human subjects, this concept has been used in a sense different from what Selye understands with stress (Groen *et al.* 1952, Milch *et al.* 1952, Mann and White 1953, Kuhl *et al.* 1955, Beischer 1956). In some investigations it is indentified with physical work or with some factor that exerts a specific stimulation on the adrenal cortex. In keeping with this diversity of concepts, a variety of terms are employed, such as stress, emotional stress, psychic stress, nervous tension, mental stress, mental and emotional strain, etc.

The measurement of an emotional disturbance is not possible. In common usage the term is employed to signify some disturbance in the emotional balance, which can be estimated only by the individual himself on the basis of his subjective sensations. Based on general experience, certain circumstances are customarily regarded as such conditions. It is also known from experience that when a man enters military service the change in the living conditions is so great that an effect on the emotional balance may be regarded as possible. On the basis of the present investigation, however, it is not possible to conclude whether the decrease in the serum lipids during the basic training period is associated with the above mentioned factors. It would seem peculiar, however, that a disturbance in the emotional balance during military service would cause a decrease in the serum lipids, since in other investigations an emotional disturbance has been found to increase the serum cholesterol. For example, Lyons (1931) and Katz and Nice (1934) found that in animals an emotional disturbance raised the serum cholesterol. Likewise in humans Dobreff *et al.* (1936) noticed increased

blood cholesterol values before surgical operations and decreased values after hypnosis. Friedman *et al.* (1958) observed in businessmen an elevated serum cholesterol level during socio-economic stress, and it has been found that during the stress of an examination there was an elevation in the serum cholesterol of students (Thomas and Murphy 1958, Wertlake *et al.* 1958, Grundy and Griffin 1959, Dreyfuss and Czaczkes 1959).

A difference in the alcohol consumption of the men during civilian life and military service might theoretically be considered a reason for the reduced serum cholesterol level during military service. The men have no opportunity to use alcohol during military service, but it is very difficult to imagine that they had used it in such quantities in civilian life as to affect the serum cholesterol level, Jankelson *et al.* (1959) having found no difference in the serum cholesterol level of heavy drinkers as compared with persons consuming a »normal» amount of alcohol. Hobson *et al.* (1953), however, noted a higher serum cholesterol level in heavy drinkers than in abstainers, and in animal experiments it has been observed that the ingestion of large amounts of alcohol has increased the serum cholesterol (Nikkilä and Ollila 1959, Gottlieb *et al.* 1959).

On the basis of the factors studied in the present investigation it appears difficult to draw conclusions concerning the reason for the decrease in serum lipids observed during military service. It seems probable that some other factor or factors are involved which did not come within the scope of this investigation.

SUMMARY

The main object of the present investigation was to study whether changes occur in the serum lipid levels of men during military service and whether the possible changes in men who are undergoing a physically heavy training differ from those in men receiving a physically light training.

The total series consisted of 187 healthy men with a mean age of 19.9 years (range 18—26 years) at the time of entering military service. About one-half of the men were given a physically strenuous infantry training and the other half were being trained for light fatigue duty. Both groups consisted of laborers and sedentary workers by civilian occupation. The men entered the service in three contingents of about the same size at intervals of four months. The serum total cholesterol, total phospholipids, and the distribution of these lipids in the α- and β-lipoprotein fractions separated by paper electrophoresis were determined in all subjects on four occasions: 1) at the beginning of military service, 2) after 8 weeks of service, 3) after 20 weeks of service, and 4) after 32 weeks of service. Observations were made of the kind and amount of diet, degree of saturation of the dietary fat content, and changes in the body weight of the men during military service.

A study was also made of the possible effect on the serum total cholesterol of the vaccinations given to the men on entering military service. For this study there were selected 33 men who were given the routine vaccinations used in the Finnish army (smallpox, tetanus, diphtheria, and *Salmonella typhi* and *paratyphi)*, and another series of 33 men who were not vaccinated. Determinations of the total cholesterol in these two series were made at the beginning of military service and after 2, 4 and 8 weeks of service.

The principal results obtained in these studies were as follows:

In the total series of 187 men the serum total cholesterol declined to a highly significant degree (from 208.8 mg per cent to 188.1 mg per cent) during the first 8 weeks. The total cholesterol remained at this reduced level throughout the service period. The fall in the total phospholipids during the first 8 weeks was also highly significant (from 221.1 mg per cent to 208.2 mg per cent). Later during the military service the total phospholipids rose significantly towards the initial level. Changes in the β-cholesterol and β-phospholipids appeared to follow the changes in the respective total amounts. There was a highly significant drop during military service in the α-cholesterol (from 56.0 mg per cent to 46.7 mg per cent) and the α-phospholipids (from 103.1 mg per cent to 97.5 mg per cent), occurring gradually during the 32 weeks of military service.

The change from the civilian diet to army diet appears to be too small to provide an explanation for the decreased serum lipids observed during military service.

Changes in the body weight of the men were not correlated to the decline in the serum lipids during military service.

The decline in the serum total cholesterol and total phospholipids in the men who were given a heavy infantry training was no greater than that in men given a physically light fatigue duty training. The changes in the lipids in the lipoprotein fractions appeared to be similar in these two groups. The degree of physical activity of the civilian occupation also had no influence on the results.

The serum lipid levels at the beginning of military service were similar in the three contingents that entered the service at intervals of 4 months (in February, June and October). The three contingents showed a similar decrease in the serum total cholesterol. There was a probable difference in the reduction in the total phospholipids between the different contingents.

No difference was observed in the reduction in the total cholesterol between the vaccinated and non-vaccinated men. A highly significant decrease occurred in the serum cholesterol of

these two groups already during the first two weeks of training (from 194.9 mg per cent to 161.6 mg per cent).

Factors that may be considered responsible for the reduced serum lipids during military service are discussed. However, no competent explanation for this circumstance could be presented.

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APPENDIX

(Tables 18—23)

TABLE 18

Mean Values and Standard Errors of the Mean for Serum Total Cholesterol and Total Phospholipids and for Their Distribution in α- and β-Lipoprotein Fractions at Different Determinations in Total Series of 187 Men

Lipid		Determination 1	2	3	4
Total cholesterol	mg%	208.8 ± 2.73	188.1 ± 2.51	190.6 ± 2.36	189.0 ± 2.61
α-cholesterol	»	56.0 ± 0.84	52.4 ± 0.80	49.8 ± 0.76	46.7 ± 0.78
β-cholesterol	»	152.7 ± 2.76	135.6 ± 2.33	140.7 ± 2.28	142.3 ± 2.55
β-cholesterol	%	72.4 ± 0.52	71.6 ± 0.44	73.4 ± 0.44	74.8 ± 0.44
Total phospholipids	mg%	221.1 ± 2.47	208.2 ± 2.20	213.9 ± 2.18	210.6 ± 2.49
α-phospholipids	»	103.1 ± 1.45	100.7 ± 1.48	98.9 ± 1.37	97.5 ± 1.50
β-phospholipids	»	118.0 ± 1.94	107.5 ± 1.77	114.9 ± 1.76	113.1 ± 1.96
β-phospholipids	%	52.9 ± 0.58	51.2 ± 0.61	53.5 ± 0.53	53.6 ± 0.55

TABLE 19

Mean Values and Standard Errors of the Mean for Serum Total Cholesterol and Total Phospholipids and for Their Distribution in α- and β-Lipoprotein Fractions at Different Determinations in Service Class Groups of 94 A-men and 93 B-men

Lipid		Service Class	Determination 1	2	3	4
Total cholesterol	mg%	A	206.4 ± 3.83	184.0 ± 3.36	189.3 ± 3.21	183.6 ± 3.21
		B	211.1 ± 3.89	192.2 ± 3.71	191.9 ± 3.46	194.6 ± 4.06
α-cholesterol	mg%	A	57.2 ± 1.08	53.3 ± 1.14	52.1 ± 1.01	48.2 ± 1.12
		B	54.8 ± 1.34	51.6 ± 1.13	47.5 ± 1.08	45.2 ± 1.05
β-cholesterol	mg%	A	149.1 ± 3.64	130.7 ± 3.07	137.1 ± 2.97	135.4 ± 2.89
		B	156.3 ± 4.15	140.5 ± 3.46	144.4 ± 3.45	149.4 ± 4.10
Total phospholipids	mg%	A	218.8 ± 3.05	203.3 ± 2.87	214.0 ± 2.94	206.4 ± 3.00
		B	223.5 ± 3.90	213.0 ± 3.28	213.8 ± 3.23	214.8 ± 3.94
α-phospholipids	mg%	A	105.0 ± 1.69	101.4 ± 2.17	101.5 ± 1.88	98.9 ± 1.94
		B	101.3 ± 2.36	100.0 ± 2.02	96.3 ± 1.96	96.2 ± 2.28
β-phospholipids	mg%	A	113.8 ± 2.40	101.9 ± 1.82	112.3 ± 2.37	107.5 ± 2.37
		B	122.2 ± 3.01	113.1 ± 2.94	117.5 ± 2.60	118.8 ± 3.02

TABLE 20

Mean Values and Standard Errors of the Mean for Serum Total Cholesterol and Total Phospholipids and for Their Distribution in α- and β-Lipoprotein Fractions at Different Determinations in Occupational Groups of 81 Sedentary Workers and 106 Laborers

Lipid		Occupation	Determination 1	2	3	4
Total cholesterol	mg%	Sedentary Workers	211.5 ± 4.48	189.1 ± 4.08	191.8 ± 4.18	189.0 ± 3.89
		Laborers	206.7 ± 3.40	187.3 ± 3.17	189.6 ± 3.00	189.1 ± 3.53
α-cholesterol	mg%	Sedentary Workers	57.1 ± 1.27	53.1 ± 1.34	52.3 ± 1.25	48.2 ± 1.30
		Laborers	55.2 ± 1.17	51.9 ± 0.99	47.9 ± 0.89	45.6 ± 0.93
β-cholesterol	mg%	Sedentary Workers	154.4 ± 4.49	135.9 ± 3.72	139.5 ± 3.69	140.8 ± 3.69
		Laborers	151.4 ± 3.48	135.3 ± 2.99	141.7 ± 4.06	143.5 ± 3.52
Total phospholipids	mg%	Sedentary Workers	222.5 ± 3.76	210.1 ± 3.56	218.8 ± 3.32	213.0 ± 3.63
		Laborers	220.0 ± 3.30	206.7 ± 2.79	210.2 ± 2.85	208.8 ± 3.40
α-phospholipids	mg%	Sedentary Workers	105.3 ± 2.18	102.3 ± 2.42	103.9 ± 1.84	101.5 ± 2.01
		Laborers	101.5 ± 1.94	99.5 ± 1.82	95.0 ± 1.75	94.6 ± 1.96
β-phospholipids	mg%	Sedentary Workers	117.3 ± 2.99	107.7 ± 2.65	114.8 ± 2.78	111.5 ± 2.77
		Laborers	118.5 ± 2.57	107.3 ± 2.38	115.0 ± 2.28	114.2 ± 2.73

TABLE 21

Mean Values and Standard Errors of the Mean for Serum Total Cholesterol and Total Phospholipids and for Their Distribution in α- and β-Lipoprotein Fractions at Different Determinations in Subgroups of 51 A-Sedentary Workers, 43 A-Laborers, 30 B-Sedentary Workers and 63 B-Laborers

Lipid		Service Class	Occupation	Determination 1	2	3	4
Total cholesterol	mg%	A	Sedentary Workers	207.8 ± 5.44	184.3 ± 5.09	188.9 ± 4.42	183.3 ± 4.26
			Laborers	204.8 ± 5.40	183.7 ± 4.26	189.7 ± 4.73	183.9 ± 4.93
		B	Sedentary Workers	217.8 ± 7.76	197.2 ± 6.65	196.7 ± 6.95	198.6 ± 7.76
			Laborers	208.0 ± 4.39	189.8 ± 4.47	189.6 ± 3.91	192.7 ± 4.87
α-cholesterol	mg%	A	Sedentary Workers	57.7 ± 1.35	53.7 ± 1.73	54.0 ± 1.38	49.4 ± 1.50
			Laborers	56.6 ± 1.75	52.7 ± 1.45	49.9 ± 1.43	46.7 ± 1.69
		B	Sedentary Workers	56.0 ± 2.58	52.0 ± 2.12	49.4 ± 2.39	46.2 ± 2.40
			Laborers	54.2 ± 1.57	51.4 ± 1.34	46.6 ± 1.12	44.8 ± 1.07
β-cholesterol	mg%	A	Sedentary Workers	150.0 ± 5.26	130.5 ± 4.56	134.9 ± 2.87	133.9 ± 3.61
			Laborers	148.1 ± 4.99	130.9 ± 4.03	139.8 ± 4.40	137.2 ± 4.69
		B	Sedentary Workers	161.8 ± 8.12	145.1 ± 6.11	147.2 ± 7.06	152.4 ± 7.47
			Laborers	153.7 ± 4.77	138.3 ± 4.20	143.0 ± 3.85	147.9 ± 4.94
Total phospholipids	mg%	A	Sedentary Workers	222.5 ± 4.62	205.5 ± 4.30	219.0 ± 3.86	211.2 ± 4.03
			Laborers	214.3 ± 3.76	200.7 ± 3.68	208.0 ± 4.39	200.8 ± 4.39
		B	Sedentary Workers	222.6 ± 6.53	217.8 ± 6.06	218.3 ± 6.19	216.2 ± 7.09
			Laborers	223.9 ± 4.88	210.8 ± 3.90	211.6 ± 3.75	214.2 ± 4.78
α-phospholipids	mg%	A	Sedentary Workers	108.5 ± 2.46	103.1 ± 3.20	107.0 ± 2.40	104.1 ± 2.45
			Laborers	100.7 ± 2.13	99.3 ± 2.87	94.9 ± 2.66	92.8 ± 2.84
		B	Sedentary Workers	99.7 ± 4.01	100.9 ± 3.66	98.6 ± 3.62	97.0 ± 4.35
			Laborers	102.0 ± 2.93	99.6 ± 2.44	95.1 ± 2.33	95.8 ± 2.68
β-phospholipids	mg%	A	Sedentary Workers	114.0 ± 3.36	102.4 ± 2.55	111.8 ± 3.17	107.0 ± 2.96
			Laborers	113.5 ± 3.30	101.4 ± 2.63	112.9 ± 3.59	108.0 ± 3.85
		B	Sedentary Workers	122.8 ± 5.45	116.8 ± 5.37	119.7 ± 5.17	119.2 ± 5.32
			Laborers	122.0 ± 3.65	111.3 ± 3.51	116.5 ± 2.97	118.5 ± 3.70

TABLE 22

Laborers	122.0 ± 3.65	111.3 ± 3.51	116.5 ± 2.97	118.5 ± 3.70

TABLE 22

Mean Values and Standard Errors of the Mean for Serum Total Cholesterol and Total Phospholipids and for Their Distribution in α- and β-Lipoprotein Fractions at Different Determinations in Three Contingents (Contingents I and II: 66 Men Each, Contingent III: 55 Men)

Lipid		Contingent	Determination 1	2	3	4
Total cholesterol	mg%	I	208.9 ± 4.83	190.7 ± 4.65	189.1 ± 4.41	200.1 ± 5.04
		II	209.2 ± 4.29	190.0 ± 4.20	194.2 ± 3.45	190.4 ± 3.78
		III	208.1 ± 5.20	182.6 ± 4.06	187.9 ± 4.30	174.1 ± 3.92
α-cholesterol	mg%	I	55.6 ± 1.49	53.7 ± 1.36	49.7 ± 1.22	47.7 ± 1.28
		II	58.2 ± 1.50	51.3 ± 1.20	50.2 ± 1.26	47.7 ± 1.41
		III	53.9 ± 1.44	52.2 ± 1.65	49.5 ± 1.50	44.3 ± 1.34
β-cholesterol	mg%	I	153.3 ± 5.26	136.9 ± 4.48	139.5 ± 4.36	152.4 ± 5.10
		II	150.9 ± 3.92	138.6 ± 3.83	144.0 ± 3.27	142.7 ± 3.57
		III	154.2 ± 5.21	130.4 ± 3.57	138.3 ± 4.15	129.9 ± 3.88
Total phospholipids	mg%	I	226.6 ± 4.85	203.9 ± 3.98	211.8 ± 3.73	223.0 ± 4.67
		II	216.5 ± 3.24	210.1 ± 3.56	219.3 ± 3.36	210.2 ± 4.11
		III	220.1 ± 4.62	211.0 ± 3.88	209.8 ± 4.28	196.3 ± 4.09
α-phospholipids	mg%	I	104.3 ± 2.74	98.8 ± 2.22	96.9 ± 2.21	100.8 ± 2.70
		II	101.5 ± 2.10	99.2 ± 2.53	103.2 ± 2.17	99.4 ± 2.13
		III	103.6 ± 2.91	104.9 ± 3.23	96.0 ± 2.93	91.3 ± 3.08
β-phospholipids	mg%	I	122.3 ± 3.85	105.0 ± 3.35	114.7 ± 3.16	122.2 ± 3.94
		II	115.0 ± 2.50	111.1 ± 3.02	116.1 ± 2.90	110.8 ± 2.56
		III	116.5 ± 3.92	106.1 ± 2.75	113.6 ± 3.39	104.9 ± 3.11

TABLE 23

Mean Weights and Ages of Different Groups

Group	Mean Weights (in kg) of Different Groups at Different Determinations — Determination 1	2	3	4	Mean Ages of Different Groups at the Beginning of Military Service
A-Sedentary Workers	68.4	68.1	69.7	70.3	19.8
A-Laborers	68.2	69.3	71.0	71.8	19.5
B-Sedentary Workers	69.9	69.1	70.3	71.2	20.9
B-Laborers	65.8	66.8	68.3	69.2	20.0
Sedentary Workers	69.0	68.5	69.9	70.7	20.3
Laborers	66.8	67.8	69.4	70.2	19.7
A-Men	68.3	68.6	70.3	71.0	19.6
B-Men	67.1	67.6	69.0	69.9	20.2
Contigent I	69.0	69.4	70.8	71.9	19.9
» II	67.5	67.3	68.9	70.0	19.9
» III	66.5	67.6	69.2	69.1	19.9
Total Series	67.7	68.1	69.7	70.4	19.9